Ohio Transportation Consortium

Undergraduate Research Internships to Support Exploratory Research in Transportation Engineering

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Project Final Report

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Table of Contents

I. Introduction

The Case Western Reserve University Department of Civil Engineering is in the process of expanding its teaching and research activities Transportation Engineering as part of its initiative in the overall area of Infrastructure Performance and Reliability. Although the Department has traditional strengths in the areas of transportation materials and structures, it is not well known for Transportation Engineering. Because of this, the Department plans to refine its recruiting strategies to make more engineering students aware of the opportunities available at Case Western Reserve University.

The goal of this 2008 OTC project was to use this funding opportunity as seed money to recruit students into transportation engineering research and to explore research activities that can become more substantial projects in subsequent years. Research initiatives will be conducted to examine transportation-related problems. The Research Internships in Transportation (RIT) program was modeled after the National Science Foundation Research Experience for Undergraduates (REU) program, which has been used successfully to recruit students into the Department's programs in Environmental and Geotechnical engineering. Ultimately, the RIT program will lead to an increase in the number of engineers pursuing advanced degrees in Transportation Engineering in the State of Ohio, and to a series of research proposals designed to help CWRU partner with other Ohio universities and professional organizations to conduct innovative transportation research.

The project was successful in recruiting four undergraduate students into the program. Two of these students were Case Western Reserve University undergraduates and two were from Fisk University. Fisk University in a predominantly African American university in Nashville, TN. The two students recruited from Fisk were both minority students underrepresented in science and engineering. The four students were:

Dan Hill – CWRU C.E. Undegraduate
Paul Mangola – CWRU C.E. Undergraduate
Maurice Gayle – Fisk Undergraduate
Mikhal Miller – Fisk Undergraduate

This group of students worked as a team on three research projects. Each student was asked to take a leadership role for one aspect of one of the projects, but, wherever possible, team efforts were used to accomplish essential tasks.

Project I - Analysis of Urban Pavement Battery Litter at Case Study Location

The analysis of battery litter on urban pavements is an ongoing research effort at CWRU. Battery litter is a major source of urban stormwater contamination and the problem originates from batteries littered on the pavements of our transportation infrastructure.

Project II - Initial Assessment of Yard Waste Carbonization Processes

Yard waste carbonization is a new research area at CWRU. The collection and separate disposal of yard waste is a problem in many communities that increases the cost of waste management transportation. The process of carbonization creates a fundamentally new option for managing this waste fraction that would allow it to be collected more efficiently and thus reduce the transportation costs of solid waste management. In addition. the carbonization process yields a commercially viable product (charcoal) that can be a beneficial soil amendment and can sequester CO_2, and byproducts that may also be of commercial value. One of these byproducts is bitumen that may be an acceptable feed stock for the production of bioasphalt.

Project III - Identification of International Soil Contamination Standards

The analysis of worldwide soil contamination standards is also an ongoing effort at CWRU. Students were asked to participate in this effort to build skills is desirable areas and to make use of the unique experiences of the recruited students.

The accomplishments in each of these three efforts are outlined in the following three chapters. Data and reports generated by the participating students have been attached as appendices.

II - Analysis of Urban Pavement Battery Litter at Case Study Location

The analysis of battery litter on urban pavements is an ongoing research effort at CWRU. Battery litter is a major source of urban stormwater contamination and the problem originates from batteries littered on the pavements of our transportation infrastructure. Research on this subject has been ongoing at CWRU since 2001. In the summer of 2008, students assisted by conducting monthly litter surveys at case study locations in the greater Cleveland area. The students also characterized all of the littered batteries recovered in these surveys and prepared data summaries for entry into a database on battery litter. The efforts of summer 2008 yielded a total of 626 littered batteries which increased the database size to data on over 7,000 littered batteries.

Field surveys were conducted at the following sites.

1. Euclid & Superior (N41^o 31.394, W81^o 35.376) **-** This site is centered on the intersection of Euclid Ave. and Superior Ave. in the City of East Cleveland. The site covers 1 block southwest and 2 blocks northeast on Euclid Ave. and 1 block to the northwest on Superior Ave. The area supports several fast food restaurants, two gas stations, and strip shopping centers. The site is served by a RTA train and RTA bus routes along Euclid Ave. and Superior Ave. The survey area includes the street pavements, the pavement around gas stations, and the strip shopping center parking spaces adjacent to Euclid Ave. There are 32 public trash receptacles, 4 pay phones, 4 bus stops with benches, and 7 retail outlets that sell batteries. Surveys cover an area of 29,540 m^2 (318,000 ft^2) and 1,531 m (5,024 ft.) of curb.

Fig. 1 – Euclid & Superior Case Study Location and Pavement Survey Areas

2. Euclid Ave (Holyoak to Lee) (N41^o 31.783, W81^o 34.950). – This site extends along Euclid Ave. from Holyoke Ave. to Lee Blvd. in the City of East Cleveland, OH. The site supports retail outlets, fast food restaurants, churches, an auto dealership, high density housing, and East Cleveland municipal offices. The East Cleveland Center shopping center and the Windermere Regional Transit Authority (RTA) parking lots are adjacent to the north boundary of the site, but neither is included in site surveys. Within the survey area there are 7 public trash receptacles, 4 pay phones, zero bus stops with benches, and 4 stores that sell batteries. Site surveys cover 1,712 m (5,618 ft.) of curb and an area of 27,500 m^2 (296,000 ft^2).

Fig. 2 – Euclid Ave (H-L) Case Study Location and Pavement Survey Area

3. Euclid Ave (Lee to Strathmore +Family Dollar) – This is a newly-established site that extends along Euclid Ave. from Lee Blvd. to Strathmore St. and includes both the street pavement and a Dollar Store parking lot in the City of East Cleveland, OH. The site was surveyed in the summer of 2007, but was not characterized in detail. The surveys conducted in 2008 were intended to determine if this should be included as an ongoing case study location.

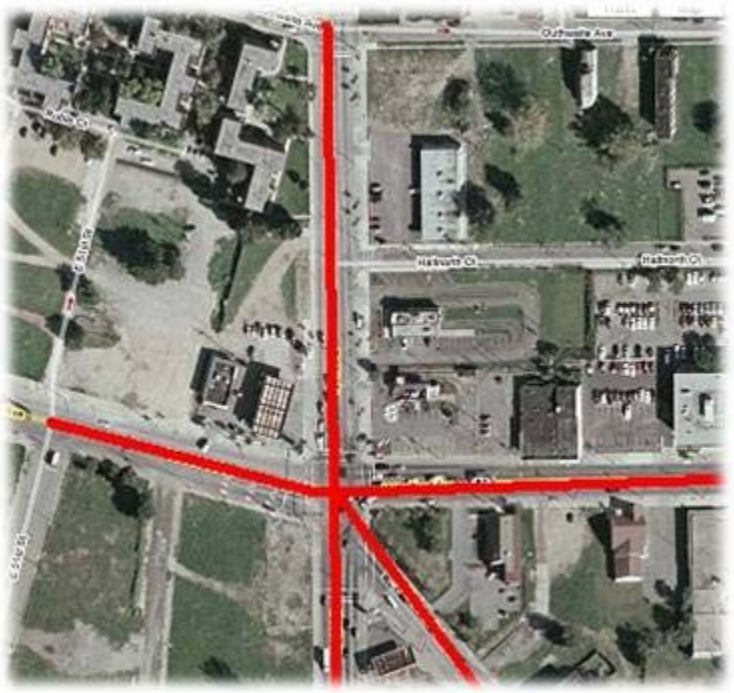
Fig. 3 – Euclid Ave (L-S +FD) Proposed Case Study Location and Pavement Survey Area

4. *Broadway Ave (N41^o 27.765, W81^o 38.768)* **-** This site extends along Broadway Ave. from Cable Ave. to Aetna Rd. in the City of Cleveland. The area supports numerous retail outlets, fast food restaurants, gas stations, and a baseball stadium. The site is adjacent to the Giant Eagle and Broadway Shoppes shopping centers, but neither is included in site surveys. Within the survey area there are 15 public trash receptacles, 1 pay phone, 3 bus stops with benches and 4 stores that sell batteries. The survey covers 1,876 (6,156 ft) of curb and a total area of 26,290 m^2 (283,000 ft^2).

Fig. 4 – Broadway Ave. Case Study Location and Pavement Survey Area

E. 55 St. (N^{o}41 29.284, W8^o 39.109) **–** This site includes 1 block on E.55 St. from Outhwaite Ave. to Woodland Ave. and Kinsman Rd. plus ½ block south of Woodland Ave. on E.55 St., ½ block east and west on Woodland Ave. and ½ block east of E. 55th St. on Kinsman Rd. in the City of Cleveland. This area supports several small stores, 2 gas stations, fast food restaurants, a small grocery store, a police substation and a post office. The main intersection has 4 seated bus stops that support RTA routes on E55th St. and Woodland Ave. There is high density housing adjacent to the northwest corner of the site and high pedestrian grade and high school traffic. Within the survey area there are 9 public trash receptacles, 5 pay phones, 5 bus stops with benches, and 4 retail outlets that sell batteries. Surveys cover 1,251 m (4,105 ft.) of street curb plus the pavement around gas stations and storefront parking. The total surface area is 23,880 m^2 (257,000 ft^2).

Fig. 5 – E. 55th Case Study Location and Pavement Survey Area



Survey were conducted monthly at each of these locations using the procedures described in Jennings and Clark (2002). All littered batteries were identified using the battery identification guide of Jennings and Kiedrowski (2008). The physical and chemical condition of all collected batteries were also quantified using the classifications schemes described by Kiedrowski (2003). The cell types were identified using the "type" classifications of Krouse (2006). All of this information was reported in the form of a site survey report and entered into the CWRU battery litter database. Data on the individual batteries collected may be found in the survey reports of Appendix A. The following tables summarize overall properties of the survey results.

Table 1 provides data on the brand distribution of the 626 littered batteries recovered in Summer 2008 surveys. Tables 2, 3 and 4 summarize the distribution of these batteries by size, cell type and by physical deterioration condition. A more detailed analysis of the battery litter survey data may be found in the project report of Paul Mangola, which is attached here as Appendix B.

Paul Mangola also assisted in updating the battery identification guide of Jennings and Kiedrowski (2008). He prepared product entries for 14 products that did not appear in the previous version of this document. Copies of these product entries have been included here in Appendix C.

Table 1 – Battery Survey Results Summarized by Battery Brands

Site (Survey Date)	Total	Duracell	Energizer	Eveready	Rayovac	Panasonic	U.S.	Int.	Unk.
Euclid & Superior (5/14/08)	58	10	8	2	0	7	5	6	20
Euclid & Superior (6/24/08)	80	17	13	4	1	12	4	12	17
Euclid & Superior (7/23/08)	56	18	4	10	0	6	1	6	11
Euclid Ave H-L (5/21/08)	38	6	8	2	0	3	4	9	6
Euclid Ave H-L (6/25/08)	45	12	15	4	0	2	1	9	2
Euclid Ave H-L (7/24/08)	42	6	9	5	0	1	6	4	11
Euclid Ave. L-S+FD(5/21/08)	36	8	3	4	0	4	7	6	4
Euclid Ave. L-S+FD (6/25/08)	39	16	8	3	1	1	3	1	6
Euclid Ave. L-S+FD (7/24/08)	18	11	5	1	1	0	0	0	0
Broadway (5/29/08)	52	15	5	9	0	11	1	5	6
Broadway (7/1/08)	51	4	7	6	0	9	1	13	11
Broadway (7/31/08)	28	7	4	5	0	4	4	2	2
55Th St (5/29/08)	29	10	3	1	1	3	2	4	5
55Th St (7/1/08)	24	5	11	0	1	1	1	2	3
55Th St (7/31/08)	30	5	10	3	1	3	2	3	3
Totals	626	150	113	59	6	67	42	82	107

U.E. – Misc. U.S. brands Int. – International Battery brands

Table 2 – Battery Survey Results Summarized by Battery Size

Site (Survey Date)	Total	AA	AAA	D	C	9v
Euclid & Superior (5/14/08)	58	40	15	0	0	2
Euclid & Superior (6/24/08)	80	49	20	4	2	0
Euclid & Superior (7/23/08)	56	38	16	0	0	0
Euclid Ave H-L (5/21/08)	38	15	22	0	0	0
Euclid Ave H-L (6/25/08)	45	29	14	1	0	0
Euclid Ave H-L (7/24/08)	42	30	12	0	0	0
Euclid Ave. L-S+FD (5/21/08)	36	25	9	1	0	1
Euclid Ave. L-S+FD(6/25/08)	39	31	8	0	0	0
Euclid Ave. L-S+FD (7/24/08)	18	15	3	0	0	0
Broadway (5/29/08)	52	35	16	0	0	0
Broadway (7/1/08)	51	28	20	1	0	1
Broadway (7/31/08)	28	22	5	0	0	0
55Th St (5/29/08)	29	20	8	1	0	0
55Th St (7/1/08)	24	17	7	0	0	0
55Th St (7/31/08)	30	24	5	0	0	0
Totals	626	418	180	8	2	4

Table 3 - Battery Survey Results Summarized by Battery Cell Type

Site (Survey Date)	Total	Type1	Type 2	Type 3	Type 2-3	Misc
Euclid & Superior (5/14/08)	58	40	12	5	0	1
Euclid & Superior (6/24/08)	80	53	16	4	0	7
Euclid & Superior (7/23/08)	56	42	8	4	0	2
Euclid Ave H-L (5/21/08)	38	21	9	7	0	1
Euclid Ave H-L (6/25/08)	45	37	5	2	0	1
Euclid Ave H-L (7/24/08)	42	30	7	3	2	0
Euclid Ave. L-S+FD (5/21/08)	36	13	22	0	0	1
Euclid Ave. L-S+FD(6/25/08)	39	32	4	1	0	2
Euclid Ave. L-S+FD (7/24/08)	18	17	1	0	0	0
Broadway (5/29/08)	52	30	18	4	0	0
Broadway (7/1/08)	51	30	11	7	1	2
Broadway (7/31/08)	28	17	10	0	0	1
55Th St (5/29/08)	29	17	7	4	0	1
55Th St (7/1/08)	24	22	1	1	0	0
55Th St (7/31/08)	30	19	9	0	1	1
Totals	626	420	140	42	4	20

Table 4 – Battery Survey Results Summarized by Physical Deterioration Rating (PDR)

Site (Survey Date)	Total	PDR=0	PDR=1	PDR=2	PDR=3	PDR=4
Euclid & Superior (5/14/08)	58	10	2	5	15	26
Euclid & Superior (6/24/08)	80	9	9	11	26	25
Euclid & Superior (7/23/08)	56	5	12	4	21	14
Euclid Ave H-L (5/21/08)	38	2	12	13	5	6
Euclid Ave H-L (6/25/08)	45	4	9	7	17	8
Euclid Ave H-L (7/24/08)	42	1	8	4	19	10
Euclid Ave. L-S+FD (5/21/08)	36	0	3	10	11	12
Euclid Ave. L-S+FD(6/25/08)	39	3	4	7	15	10
Euclid Ave. L-S+FD (7/24/08)	18	0	1	7	10	0
Broadway (5/29/08)	52	8	11	4	14	15
Broadway (7/1/08)	51	3	10	10	9	19
Broadway (7/31/08)	28	4	8	3	4	9
55Th St (5/29/08)	29	4	11	3	5	6
55Th St (7/1/08)	24	0	10	2	8	4
55Th St (7/31/08)	30	5	5	5	6	9
Totals	626	58	115	95	185	173

III. Initial Assessment of Yard Waste Carbonization Processes

Urban yard waste poses solid waste management difficulties for many communities. In many areas, municipal solid waste is disposed of in sanitary landfills. However, yard waste may not be landfilled. Communities must collect and dispose of this separately. With the increasing cost of fuel, separate yard waste collection is an increasing financial burden on these communities. Furthermore, there are few waste management alternatives for yard waste. Most communities compost the waste but this is not an ideal solution:

i. Composting takes time, energy, and a significant amount of land.
ii. Yard waste compost is not in demand as a consumer product.
iii. Composting yard waste releases all of the CO_2 potential of this organic waste fraction.

A project was initiated at CWRU to evaluate a different method of managing yard waste. This project evaluated the potential of managing yard waste by carbonization. This offers the possibility of allowing for co-collection, yard waste management at landfill sites, production of soil amendment products that permanently sequester CO_2, and production of other valuable byproducts **including the possibility of recovering bitumen that could be used to manufacture of non-petroleum-based bioasphalt.**

Students participated in four phases of the project (i) a laboratory-scale apparatus was developed for proof-of-concept testing of the carbonization process (ii), a series of yard waste components were collected and carbonized to determine their carbon and byproduct yield potential , (iii) a pilot-scale apparatus was developed that is capable of carbonizing yard waste in large volume, and (iv) plant growth experiments were conducted to determine the degree to which charcoal made from urban yard waste can serve as a soil amendment. Where appropriate, all students participated in all phases, but Dan Hill assumed the leadership role and was responsible for data generation and analysis.

Laboratory-Scale Apparatus

The laboratory-scale apparatus constructed for this project is illustrated in Fig.6. The device makes use of an existing muffle furnace capable of temperatures in excess of 500 C, gas discharged piping and a byproduct recovery system located under a laboratory hood in the Environmental Engineering Laboratory of the Bingham Engineering Building. The apparatus is capable of carbonizing yard waste components in volumes of approximately 1 liter.

Fig. 6 – Laboratory Scale Yard Waste Carbonization Apparatus

Yard Waste Component Analysis

Once the laboratory-scale carbonization unit had been assembled and tested (using hardwood chips) (see Fig. 7) , teste were conducted on 22 yard waste fractions ranging from wet grass clippings to dry hardwood chips (see Fig. 8). All of the yard waste products used were collected in the cities of Shaker Heights and Cleveland Heights on yard waste disposal days.

Fig. 7 - Hardwood chips before and after carbonization

Fig. 8 Yard waste components before and after carbonization

Table 5 summarizes the types of yard waste fractions tested and the fractional yield of charcoal, water (condensed from steam) and organic component recovered from each fraction. During these experiments, it was observed that a bituminous material (AKA wood tar, Pitch, Resin ?) formed (see Fig. 9) and could plug the discharge piping. Originally, this was viewed as a problem, but it was rapidly realize that it is also an opportunity. The piping can easily be designed so it is not plugged by this material, and the bitumen can be collected as a valuable byproduct. This is how wood tars were manufactured before the petroleum era. This could be used in the production of bioasphalt. A research project to explore this aspect of the research has been proposed to the Ohio Department of Transportation.

The average organic product yield from yard waste carbonization was 28.7 % This has the potential to produce a very large quantity of bitumen. The population of Cuyahoga County is approximately 1.4 million people (560,000 households). The average municipal solid waste generation rate is approximately 5 lbs/c-d. Yard waste accounts for approximately 12 % of municipal solid waste.

Yard Waste Generation: (1,400,000c)(5 lbs/c-d)(365d/yr)(0.12)/(2000 lbs/T) = 153,300 T/yr

Carbonization Organic Byproduct Yield: 153,300 T/yr*0.287 = 43,998 T/yr

Yard waste carbonization in Cuyahoga County alone could yield 40,000 tons of organic byproduct annually. Obviously not all of this would be bitumen, but a large fraction of this could be used in the production of bioasphalt.

Table 5 – Results of Carbonization of Yard Example Yard Waste Component Fractions

Yard Waste Component	% Charcoal	%Water	%Organic
Oak Leaves (dry)	43.0	19.4	37.6
Maple Leaves (green)	56.2	11.1	32.7
Mugo Pine needles	25.2	53.1	21.7
Oak Branches	38.2	24.5	37.3
Maple Branches	34.5	19.0	46.5
Mugo Pine Branches	42.7	11.7	45.6
Misc. Leaves	53.1	21.2	25.7
Maple Leaves (dry)	52.8	11.7	35.5
Grass Clippings	12.3	68.8	18.9
Fir Needles (green)	30.9	51.8	17.3
Fir Branches (green)	45.8	45.4	8.8
Beech leaves (green)	55.1	6.7	38.2
Beech branches (green)	43.2	26.0	30.9
Cottonwood Branches (green)	35.2	38.2	26.7
Cottonwood Leaves (green)	35.5	50.0	14.5
Pine Cones (green)	19.5	61.0	19.5
Pine Cones (dry)	36.6	40.3	23.1
Pear Leaves (green)	54.7	8.3	37.0
Pear branches (green)	31.5	41.1	27.3
Average	39.3	32.1	28.7

Fig.9 – Bitumen Produced During Yard Waste Carbonization

Pilot-scale Carbonization Apparatus

A pilot-scale carbonization apparatus (see Fig. 10) was constructed and tested. An industrial over was acquired and instrumented with a digital temperature controller. A reactor capable of holding approximately 100 l batches of yard waste was fabricated and installed. A byproduct and offgas recovery system was also fabricated. Dan Hill participated in the design and assembly of all components. Initial tests indicate that the reactor is capable of accomplishing carbonization in about 4 hours. However, the initial tests also indicated that the vent stack used to discharge uncondensed gas may not reach high enough above the Bingham Engineering Building to ensure that offgas is not captured by the building's nearby air intakes. A chimney extension is currently being designed and will be installed before the pilot-scale apparatus goes into full production.

Fig. 10 – Pilot-scale Apparatus for Yard Waste Carbonization and Byproduct Recovery

Plant Growth Experiments

All of the research participants took part in plant growth experiments being conducted at CWRU's Valleevue Farm research facility to examine the effect of adding carbonized yard waste to soils. The initial set of experiments were conducted on soybean plantings. All of the students assisted in setting up the initial plantings, and in our ongoing process of gauging the relative growth in different types of soils amended to different degrees with carbonized yard waste. Figure 11- 16 provides examples of images taken later in the summer to gauge plant growth. The crop did not reach maturity while the students were engaged in the project, but has since reached maturity and been harvested. The data generated from this original planting will be used in proposals for continued research on this subject.

Fig. 11 - CWRU's Valleevue Farm Research Greenhouse

Fig. 13 - Dan Hill Preparing Soybean Planting Pots

Fig. 13 Paul Mangola and Maurice Gayle Preparing Charcoal-Amended Soils

Fig. 14 – Soybean Planting (Day 1)

Fig. 15 – Soybean Planting After Sprouting.

Fig. 16 – Soybean Plant Photographed of Differential Growth Quantification

IV. Identification of International Soil Contamination Standards

The analysis of U.S. and worldwide soil contamination standards is also an ongoing effort at CWRU. Dr. Jennings is a well-published authority on this subject. Previous efforts (see Jennings and Hanna, 2008, Jennings 2008) led to the assembly of a database titled **S^3RGV** (State Surface Soil Regulatory Guidance Values) that contains data on soil contamination of all 50 U.S. states, and to **IS^2RGV**(International Surface Soil Regulatory Guidance Values). These are supporting some very interesting analysis of how our soil contamination efforts are emerging in the U.S. and worldwide. However, it is much easier to identify U.S. regulations because of familiarity with state regulatory structures and our common use of English. It is reasonably easy to identify similar regulations in Canada and European countires, but it becomes substantially more difficult to do so elsewhere in the world.

The students were asked to assist in this process by conducting internet searches for surface soil regulations in countries anywhere in the world that had not been previously identified. These efforts were headed by Mr. Miller and Mr. Gayle who were asked to concentrate their efforts on the countries of Central and South America

The results of these efforts were quite fruitful. The students identified soil standards for 16 nations that had not been previously identified (see Table 6). Standards have now been identified for the following nations.

> ***Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Bulgaria, Canada, Czech Republic, China, Northern Mariana Islands, Denmark, Equator, Estonia, Finland, France, Germany, Hong Kong, Hungary, Italy, Jamaica, Japan, Lithuania, Mexico, Netherlands, New Zealand, Norway, Poland, Puerto Rico, Moldova, Romania, Russia, Slovakia, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Trinidad and Tobago, United Kingdom, Uzbekistan and Vietnam. The UN also has soil contamination recommendations.***

Although this task did not relate directly to Transportation Engineering, it allowed the students to participate on a fundamentally different aspect of engineering research, help improve their professional communication skills, and helped generate enthusiasm for more advanced studies. It also provided data that will be valuable to future research efforts at CWRU. Any publication that makes use of this data will acknowledge the student's participation and the OTC funding source. Appendix D provides additional details on the accomplishments of Mikhal Miller. Appendix E provides additional details on the accomplishments of Maurice Gayle.

Table 6 – Soil Standard Sources Identified in Summer 2008 Research

Nation	Standards Characterization	Number	#O	#I	#E
Thailand	Soil Quality Standards	36	27	1	8
Romania	Maximum Allowable Limits	7	0	0	7
CNMI	Environmental Screening Levels (ESLs)	120	98	2	20
UN-FAO	Permissialbe Concentrations	36	36	0	0
Argentina	Environmental Media Maximum	2	0	0	2
Mexico	Standards for Environmental Media	1	0	0	1
Bolivia	Soil Limit Value	1	0	0	1
Trinidad and Tobago	Maximum Level of Discharge to Soil and Sediment	2	0	0	2
Equador	Soil Quality Criteria	2	0	0	2
Russian Federation	Environmental Quality Standards	3	0	0	3
Republic of Moldova	Environmental Quality Standards	2	0	0	2
Romania	in soil and sediment	2	0	0	2
Norway	Most Sensitive land Use	1	0	0	1
Jamaica	Interim Standards for Soil	6	6	0	0
Puerto Rico	Corrective Action Requirements	9	8	0	1
Uzbekistan	Major Environmental Standards	1	0	0	1
Totals		231	175	3	53

#0 – Number of standards for organic contaminants

#I – Number of standards for inorganic contaminants

#E – Number of standards for elements

CNMI – Commonwealth of the Northern Mariana Islands

In order to understand something about the contaminants regulated in soil contamination regulations, Mr. Gayle and Mr. Miller were also asked to develop brief summaries of the properties of the most frequently regulated synthetic organic chemicals.

Summaries by Maurice Gayle:

1,1Dichloroethane (CAS No. 73-34-3)

Dieldrin (CAS No. 60-57-1)

1,4 Dichlorobenzene (CAS No. 106-46-7)

1,1,2 Trichloroethane (CAS No. 79-00-5)

1,2 Dichloroethene (CAS No. 156-60-5)

1,2 Dichlorobenzene (CAS No. 95-50-1)

1,1 Dichloroethene (CAS No. 75-35-4)

Lindane (CAD No. 58-89-9)

Chlorobenzene (CAS NO 108-90-7)

Hexachlorobenzene (CAS No 118-74-1)

Summaries by Mikhail Miller

Trichloroethylene (CAS No. 79-01-6)

Tetrachloroethylene (CAS No.

Methylene Chloride (CAS No. 75-09-2)

Carbon Tetrachloride (CAS No. 56-23-5)

Chloroethene (CAS No 75-01-4)

Pentachlorophenol (CASNo. 87-86-5)

1,1,1 Trichloroethane (CAS No. 71-55-6)

Chloroform (CAS No. 67-66-3)

DDT (CAS No. 50-29-3)

All of these summaries have been included in Appendix F. Any publication that makes use of this information will acknowledge the student's participation and the OTC funding source.

References

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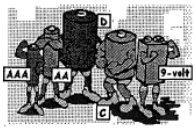
Appendix A –

Field Site Battery Litter Survey Results

Dr. Aaron A. Jennings
Dan Hill
Paul Manglona
Maurice Gayle
Mikhal Miller

Summer 2008



CWRU Feral Battery Research Project
Feral Battery Identification Report

IN DATABASE

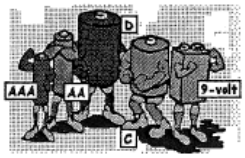
Site Location: Euclid and Superior **Date** 5/14/08

Team Identification: Jennings, P. Manglona

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel, 2. Steel/zinc, 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Energizer Alkaline	AA	1	2	2
2	Energizer Alkaline	AA	1	1	2
3	Energizer Alkaline	AA	1	2	3
4	Energizer Alkaline	AA	1	2	3
5	Energizer Alkaline	AA	1	2	3
6	Energizer Alkaline	AAA	1	1	0
7	Energizer Alkaline	AAA	1	2	0
8	Energizer Alkaline	AAA	1	2	3
9	Panasonic Super Heavy Duty	AA	2	3	4
10	Panasonic Super Heavy Duty	AA	2	4	4
11	Panasonic Super Heavy Duty	AA	2	3	0
12	Panasonic Super Heavy Duty	AA	2	4	4
13	Panasonic Super Heavy Duty	AA	2	4	4
14	Panasonic Alkaline Plus	AAA	2?1	0	0
15	Panasonic Alkaline Plus	AA	1	4	3
16	Duracell Pile Alcaline	AA	1	2	3
17	Duracell Alkaline	AA	1	2	0
18	Duracell Pile Alcaline	AA	1	2	1
19	Duracell Ultra	AAA	1	1	0
20	Duracell Pile Alcaline	AA	1	3	3

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



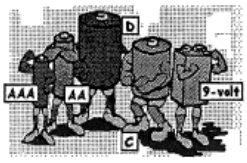
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
21	Duracell Alkaline	AAA	1	3	2
22	Duracell	AA	1	3	4
23	Duracell	AA	1	3	4
24	Duracell	AA	1	2	3
25	Duracell	AA	1	3	3
26	Eveready Super Heavy Duty	AA	2	3	4
27	Eveready Super Heavy Duty	AA	2	4	4
28	Q-Force Heavy Duty	AAA	3	0	0
29	Q-Force Heavy Duty	AA	3	3	4
30	GP Alkaline	AAA	1	2	0
31	Magnavox Super Heavy Duty	AAA	(1) x2	1	1
32	Philips Powerlife	AAA	1	1	0
33	Rocket Ultragreen	AAA	3	2	2
34	Walgreens Ultra Alkaline Supercell	AA	~~2~~ 1	4	4
35	Walgreens Ultra Alkaline Supercell	AA	~~2~~ 1	4	4
36	Finast Alkaline	AA	1	3	0
37	Unknown	AA	2	4	4
38	Fuji Novel Super Alkaline	AA	1	4	4
39	Unknown	AA	1	4	4
40	Walgreens Procell	9V	2	4	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



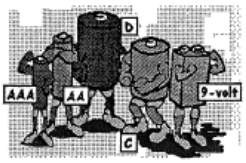
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
41	Unknown	AA	3	4	4
42	Unknown	AA	3	4	4
43	Unknown	AA	1	3	4
44	Unknown	AA	1	3	3
45	Unknown	AA	1	3	3
46	Unknown	AA	1	4	3
47	Unknown	AA	2	4	4
48	Unknown	AAA	1	3	3
49	unknown	AAA	1	4	4
50	unknown	AA	1	4	3
51	unknown	AA	1	4	4
52	unknown	AA	1	4	4
53	unknown	AA	1	4	4
54	unknown	AAA	1	4	4
55	unknown	AAA	1	3	3
56	unknown	AA	1	4	4
57	unknown	9V	1	4	4
58	unknown Lithium Cellphone batt.			1	2
59					
60					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	10
Energizer	8
Eveready	2
Rayovac	0
Panasonic	7
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	4 3
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	2
Misc. International Labels (Novel, Okkaido, ...)	6
Unknown (can't be determined from label)	20
Total	58

Summary of Battery Cell Size

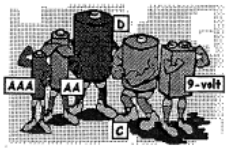
Battery Size	Number
AA	40
AAA	15
D	0
C	0
9V	2
Other	1
Total	58

Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	40
Type 2 – Zinc barrel with steel sheath	12
Type 3 – Zinc barrel with paper/plastic label	5
Type 2-3 (zinc barrel of uncertain origin)	0
Other	1
Total	58

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	10
1 – Minor "scuffing" damage	2
2 – Scuffing and relatively minor deformation	4 5
3 - Major deformation but still intact	15
4 – Highly deformed and/or ruptured	26
Total	58



CWRU Feral Battery Research Project
Feral Battery Identification Report

IN DATABASE

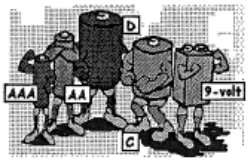
Site Location: Euclid Ave, Lee to Strathmore + FD **Date** 5/21/08

Team Identification: Jennings, P. Manglona, D. Hill

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
1	Panasonic Super Heavy Duty	AA	2	2	4
2	Panasonic Super Heavy Duty	AA	2	3	4
3	Panasonic Super Heavy Duty	AA	2	3	2
4	Panasonic Super Heavy Duty	AA	2	4	4
5	Eveready Super Heavy Duty	AA	2	4	4
6	Eveready Super Heavy Duty	AA	2	4	4
7	Eveready Super Heavy Duty	AA	2	4	4
8	Eveready Super Heavy Duty	AAA	2	4	4
9	Energizer Alkaline	AA	1	3	3
10	Energizer Alkaline	AA	1	3	4
11	Energizer Industrial	AA	1	3	4
12	Duracell Copper Top	AAA	1	1	2
13	Duracell Copper Top	AA	1	2	2
14	Duracell Copper Top	AA	1	2	2
15	Duracell Copper Top	AA	1	2	3
16	Duracell Copper Top	AA	1	2	3
17	Duracell Copper Top	AA	1	3	3
18	Duracell Procell	AAA	1	2	3
19	Duracell Rechargeable	AA	1	2	2
20	Mighty Energy	AAA	1	2	1

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



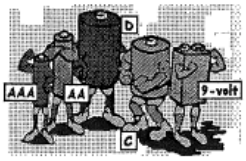
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
21	Sunbeam Super Heavy Duty	AA	2	1	3
22	Sunbeam Super Heavy Duty	AA	2	2	3
23	Sunbeam Super Heavy Duty	AA	2	1	3
24	Walgreens Heavy Duty Powercell	AA	2	0	2
25	Walgreens Heavy Duty Powercell	AA	2	0	2
26	Walgreens Heavy Duty Powercell	AAA	2	3	3
27	Walgreens Ultra Alkaline Supercell	AAA	~~2~~ 1	2	1
28	Walgreens Ultra Alkaline Supercell	AAA	~~2~~ 1	3	2
29	Walgreens Ultra Alkaline Supercell	AA	~~2~~ 1	3	2
30	Samsung Pleomax	AAA	2	2	1
31	CVS Alkaline (Version 2)	AA	~~2~~ 1	2	3
32	GP Powercell	9V	2	2	2
33	Unknown	AAA	2	4	4
34	unknown	AA	1	3	3
35	Unknown	AA	2	4	4
36	unknown	D	unknown	3	4
37					
38					
39					
40					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	8
Energizer	3
Eveready	4
Rayovac	0
Panasonic	4
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	7
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	6
Unknown (can't be determined from label)	4
Total	36

Summary of Battery Cell Size

Battery Size	Number
AA	25
AAA	9
D	1
C	0
9V	1
Other	0
Total	36

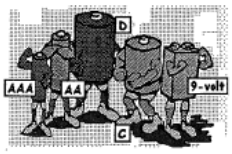
Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	13
Type 2 – Zinc barrel with steel sheath	22
Type 3 – Zinc barrel with paper/plastic label	0
Type 2-3 (zinc barrel of uncertain origin)	0
Other	1
Total	36

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	0
1 – Minor "scuffing" damage	3
2 – Scuffing and relatively minor deformation	10
3 - Major deformation but still intact	11
4 – Highly deformed and/or ruptured	12
Total	36

IN DATABASE



CWRU Feral Battery Research Project
Feral Battery Identification Report

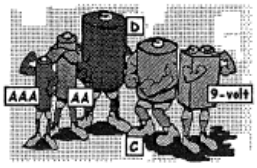
Site Location: Euclid Avenue, Holbyoke/Belmone to Lee **Date** 5/21/08

Team Identification: Jennings, P. Manglona, D. Hill

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel 2. Steel/zinc 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Panasonic, super Heavy Duty	AA	2	3	1
2	Panasonic, super Heavy Duty	AA	2	3	1
3	Panasonic, super Heavy Duty	AA	2	4	4
4	Duracell Copper Top	AA	1	3	2
5	Duracell Copper Top	AA	1	2	2
6	Duracell Copper Top	AA	1	2	2
7	Duracell Copper Top	AAA	1	1	1
8	Duracell Copper Top	AAA	1	3	3
9	Energizer Alkaline	AA	1	2	1
10	Energizer Alkaline	AA	1	3	2
11	Energizer Alkaline	AAA	1	2	2
12	Energizer Alkaline	AAA	1	0	0
13	Energizer Alkaline	AAA	1	3	1
14	Energizer Alkaline	AAA	1	2	2
15	Energizer Alkaline	AAA	1	3	2
16	Duracell Procell	AAA	1	3	1
17	Q-Force Heavy Duty	AAA	3	0	0
18	Q-Force Heavy Duty	AAA	3	0	1
19	Q-Force Heavy Duty	AAA	3	4	4
20	Q-Force Super Heavy Duty	AAA	3	0	2

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



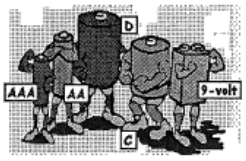
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
21	Q-Force Super Heavy Duty	AAA	3	2	3
22	Eveready Super Heavy Duty	AA	2	3	3
23	Eveready GOLD	AA	1	3	1
24	Expocell Super Heavy Duty	AAA	3	1	1
25	Zhenli extra Heavy Duty	AAA	3	1	1
26	CVS pharmacy	AAA	1	3	2
27	Walgreens Ultra Alkaline Supercell	AA	1	3	2
28	Energizer Lithium	AA	1	2	2
29	Rite Aid Alkaline	AAA	1	2	2
30	Walgreens Ultra-Alkaline Supercell	AAA	1	1	2
31	Metro Blackcell	AAA	1	0	1
32	LG Lithium Ion Cellphone batt. (3.7v)			0	1
33	Unknown	AA	1	2	3
34	Unknown	AA	2	4	4
35	Unknown	AA	2	4	4
36	Unknown	AAA	1	4	3
37	Unknown	AAA	1	3	4
38	Unknown	AAA	1	4	4
39					
40					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	6
Energizer	8
Eveready	2
Rayovac	0
Panasonic	3
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	4
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	9
Unknown (can't be determined from label)	6
Total	38

Summary of Battery Cell Size

Battery Size	Number
AA	15
AAA	22
D	
C	
9V	
Other	1
Total	38

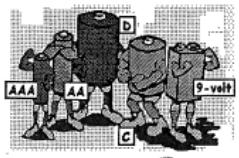
Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	21
Type 2 – Zinc barrel with steel sheath	9
Type 3 – Zinc barrel with paper/plastic label	7
Type 2-3 (zinc barrel of uncertain origin)	
Other	1
Total	38

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	2
1 – Minor "scuffing" damage	12
2 – Scuffing and relatively minor deformation	13
3 - Major deformation but still intact	5
4 – Highly deformed and/or ruptured	6
Total	38

IN DATABASE



CWRU Feral Battery Research Project
Feral Battery Identification Report

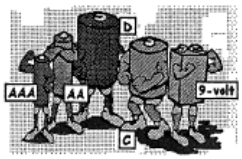
Site Location: Broadway Ave: Aetna Rd to Blanche **Date** 05/29/08

Team Identification: Jennings, P. Manglona, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel, 2. Steel/zinc, 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Duracell Coppertop	AA	1	2	1
2	Panasonic super heavy duty	AA	2	3	2
3	Duracell Copper Top	AA	1	1	0
4	Duracell Copper Top	AA	1	1	0
5	Duracell Copper Top	AA	1	0	0
6	Duracell Copper Top	AA	1	2	0
7	Duracell Copper Top	AA	1	1	0
8	Duracell Copper Top	AA	1	0	0
9	Duracell Copper Top	AA	1	1	3
10	Duracell Copper Top	AA	1	3	3
11	Duracell Copper Top	AA	1	3	3
12	Duracell Copper Top	AAA	1	0	1
13	Duracell Copper Top	AAA	1	1	0
14	Duracell Copper Top	AAA	1	1	1
15	Duracell Copper Top	AAA	1	2	1
16	Duracell Ultra	AA	1	2	1
17	Panasonic Super Heavy Duty	AA	2	2	1
18	Panasonic Super Heavy Duty	AA	2	3	2
19	Panasonic Super Heavy Duty	AA	2	3	1
20	Panasonic Super Heavy Duty	AA	2	2	2

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

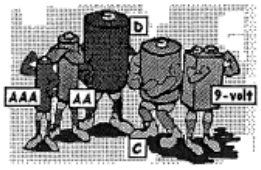
(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
21	Panasonic Super Heavy Duty	AA	2	3	2
22	Panasonic Super Heavy Duty	AA	2	4	4
23	Panasonic Super Heavy Duty	AA	2	4	4
24	Panasonic Super Heavy Duty	AA	2	4	4
25	Panasonic Super Heavy Duty	AAA	2	0	3
26	Eveready Super Heavy Duty	AA	2	2	3
27	Eveready Super Heavy Duty	AA	2	3	3
28	Eveready Super Heavy Duty	AA	2	3	3
29	Eveready Super Heavy Duty	AA	2	4	4
30	Eveready Super Heavy Duty	AAA	2	2	1
31	Eveready Super Heavy Duty	AAA	2	4	4
32	Eveready Gold	AA	1	1	3
33	Eveready Gold	AA	1	0	0
34	Eveready Gold	AAA	1	1	1
35	Energizer	AA	1	2	3
36	Energizer	AA	1	3	4
37	Energizer	AA	1	3	4
38	Energizer	AAA	1	3	4
39	ULTRA LAST (rechargeable)	AAA	1	0	1
40	LARGE ALKALINE BATT.	AA	1	3	1

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):

1



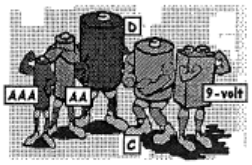
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
41	Q-Force	AA	3	2	4
42	Q-Force	AAA	3	1	3
43	Q-Force	AAA	3	3	3
44	Dorcy Mastercell Heavy Duty	AAA	3	2	3
45	Unknown	AA	1	3	4
46	unknown	AA	2	4	4
47	unknown	AA	1	4	4
48	unknown	AA	1	4	4
49	unknown	AAA	1	4	4
50	unknown (12V button stack)	other	1	4	3
51	energizer	AAA	1	3	3
52	Panasonic Super Heavy Duty	AAA	2	4	4
53					
54					
55					
56					
57					
58					
59					
60					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	15
Energizer	5
Eveready	9
Rayovac	0
Panasonic	11
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	0
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	1
Misc. International Labels (Novel, Okkaido, ...)	5
Unknown (can't be determined from label)	6
Total	52

Summary of Battery Cell Size

Battery Size	Number
AA	35
AAA	16
D	0
C	0
9V	0
Other	1
Total	52

Summary of Battery Barrel Type

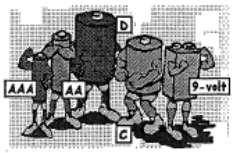
Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	30
Type 2 – Zinc barrel with steel sheath	18
Type 3 – Zinc barrel with paper/plastic label	4
Type 2-3 (zinc barrel of uncertain origin)	0
Other	0
Total	52

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	8
1 – Minor "scuffing" damage	11
2 – Scuffing and relatively minor deformation	4
3 - Major deformation but still intact	14
4 – Highly deformed and/or ruptured	15
Total	52

$\mu = 2.33$

IN DATABASE



CWRU Feral Battery Research Project
Feral Battery Identification Report

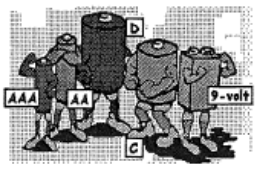
Site Location: 55th St **Date** 05/27/08

Team Identification: Maurice Gayle, Mikhail Miller, Paul Mandona

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel, 2. Steel/zinc, 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Duracell copper top	AA	1	1	2
2	Duracell copper top	AA	1	2	1
3	Duracell copper top	AAA	1	1	1
4	Duracell copper top	AA	1	1	1
5	Duracell copper top	AAA	1	4	4
6	Duracell copper top	AA	1	2	1
7	Duracell copper top	AA	1	1	1
8	Duracell copper top	AA	1	3	3
9	Duracell copper top	AA	1	3	3
10	Energizer e^2	AA	1	1	1
11	Energizer e^2	AA	1	1	1
12	Energizer e^2	AA	1	0	0
13	Panasonic super heavy duty	AA	2	0	0
14	Panasonic super heavy duty	AAA	2	0	3
15	Panasonic super heavy duty	AAA	2	3	2
16	~~Panasonic~~ Walgreens heavy duty	AA	2	0	1
17	Eveready super heavy duty	AA	2	2 3	2
18	Jiafuli Extra heavy duty	AA	3	0	1
19	~~Eveready~~ Pleomax super heavy duty	AA	2	0	3
20	Rite Aid Alkaline	AAA	1	0	1

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



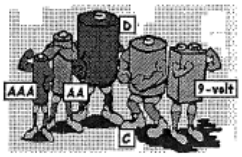
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
21	Pleomax super heavy duty	~~AA~~	2	0	0
22	Q-Force heavy duty	~~AA~~	3	2	1
23	Rayovac max. plus	~~AAA~~	1	0	0
24	Unidentified	~~AAA~~	3	4	4
25	Unidentified	~~AA~~	3	3	3
26	Unidentified	~~AAA~~	~~2~~ 1	4	4
27	Unidentified	~~AA~~	1	4	4
28	~~Unidentified~~ unidentified	D	Unknown	~~4~~ 4	~~4~~ 4
29	Duracell	~~AA~~	1	4	4
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	10
Energizer	3
Eveready	1
Rayovac	1
Panasonic	3
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	2
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	~~1~~ 4
Unknown (can't be determined from label)	5
Total	29

Summary of Battery Cell Size

Battery Size	Number
AA	20
AAA	8
D	1
C	0
9V	0
Other	0
Total	29

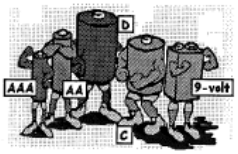
Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	~~17~~ 17
Type 2 – Zinc barrel with steel sheath	~~7~~ 7
Type 3 – Zinc barrel with paper/plastic label	4
Type 2-3 (zinc barrel of uncertain origin)	0
Other	1
Total	29

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	4
1 – Minor "scuffing" damage	11
2 – Scuffing and relatively minor deformation	3
3 - Major deformation but still intact	5
4 – Highly deformed and/or ruptured	~~5~~ 6
Total	29

$\mu = 1.83$



IN DATABASE

CWRU Feral Battery Research Project
Feral Battery Identification Report

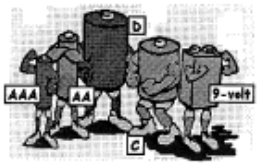
Site Location: EUCLID & SUPERIOR **Date** 6/24/08

Team Identification: Jennings, P. Mangluna, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
1	Panasonic Super Heavy Duty	AA	2	3	4
2	Panasonic Super Heavy Duty	AA	2	2	2
3	Panasonic Super Heavy Duty	AA	2	4	4
4	Panasonic Super Heavy Duty	AA	2	4	4
5	Panasonic Super Heavy Duty	AA	2	3	4
6	Panasonic Super Heavy Duty	AA	2	4	4
7	Panasonic Super Heavy Duty	AA	2	4	4
8	Panasonic Super Heavy Duty	AAA	2	2	4
9	Panasonic Super Heavy Duty	D	~~unknown~~ 2	0	4
10	Panasonic Super Heavy Duty	D	~~unknown~~ 2	1	4
11	Panasonic Super Heavy Duty	D	~~unknown~~ 2	1	4
12	Panasonic Rechargeable	AA	1	1	2
13	Duracell Copper Top	AA	1	2	3
14	Duracell Copper Top	AA	1	2	3
15	Duracell Copper top	AA	1	1	3
16	Duracell Copper Top	AA	1	2	3
17	Duracell Copper Top	AA	1	1	3
18	Duracell Copper Top	AA	1	2	3
19	Duracell Copper Top	AA	1	1	3
20	Duracell Copper Top	AA	1	1	3

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



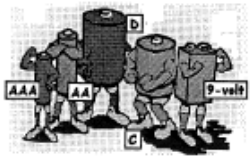
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
21	Duracell Copper Top	AA	1	3	1
22	Duracell Copper Top	AA	1	1	0
23	Duracell Copper Top	AA	1	2	0
24	Duracell Copper Top	AA	1	0	1
25	Duracell Copper Top	AAA	1	1	2
26	Duracell Copper Top	AAA	1	2	4
27	Duracell Copper Top	AAA	1	2	3
28	Duracell Copper Top	AAA	1	2	4
29	Duracell Ultra	AA	1	1	1
30	Energizer	AA	1	0	0
31	Energizer	AA	1	0	0
32	Energizer	AA	1	1	0
33	Energizer	AA	1	1	0
34	Energizer	AA	1	0	0
35	Energizer	AA	1	2	0
36	Energizer	AA	1	2	3
37	Energizer	AA	1	2	3
38	Energizer	AA	1	1	3
39	Energizer	AAA	1	3	2
40	Energizer	AAA	1	1	1

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



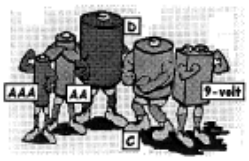
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
41	Energizer	AAA	1	2	2
42	Energizer Industrial	AAA	1	2	2
43	EVEREADY GOLD	AA	1	1	1
44	Eveready Gold	AA	1	3	1
45	Eveready Gold	AAA	1	1	3
46	Rayovac Maximum Plus	AA	1	1	2
47	EVeready Super Heavy Duty	AA	2	3	1
48	GP Alkaline	AAA	1	1	1
49	Alkaline Battery	AAA	1	3	2
50	Q-Force	AAA	3	0	3
51	Sunbeam Super Heavy Duty	AA	2	0	0
52	DG Xtra Heavy Duty	AA	3	3	4
53	DG Xtra Heavy Duty	AA	3	1	3
54	Laser Cell	AA	1	0	3
55	Laser Cell	AA	1	0	3
56	Toshiba Alkaline	AA	1	1	3
57	Rite Aid Alkaline	AA	1	2	3
58	Rite Aid Alkaline	AAA	1	1	2
59	Walgreens Heavy Duty Powercell	AAA	2	4	4
60	Walgreen Heavy Duty Powercell	AAA	2	3	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



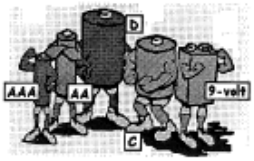
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
61	Streetwise CR2 Lithium	3V	unknown	3	1
62	Streetwise CR2 Lithium	3V	unknown	3	3
63	Streetwise CR2 Lithium	3V	unknown	3	3
64	unknown	AAA	~~unk~~ 1	4	4
65	unknown	AA	1	4	4
66	unknown	AA	1	3	3
67	unknown	AA	1	2	3
68	unknown	AA	1	4	4
69	unknown	AA	1	3	3
70	unknown	AAA	1	4	4
71	unknown	AA	3	4	3
72	unknown	AA	1	3	4
73	unknown	AAA	1	3	3
74	unknown	C	1	2	4
75	unknown	C	1	2	4
76	unknown	AA	unknown	4	4
77	unknown	button cell	unknown	3	2
78	unknown	button cell	unknown	2	2
79	unknown	AA	2	4	4
80	unknown	D	unknown	4	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	17
Energizer	13
Eveready	4
Rayovac	1
Panasonic	12
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	4
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	12
Unknown (can't be determined from label)	17
Total	80

Summary of Battery Cell Size

Battery Size	Number
AA	49
AAA	20
D	4
C	2
9V	0
Other	5
Total	80

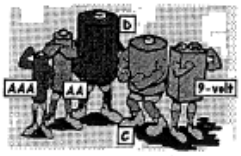
Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	53
Type 2 – Zinc barrel with steel sheath	16
Type 3 – Zinc barrel with paper/plastic label	4
Type 2-3 (zinc barrel of uncertain origin)	0
Other	7
Total	80

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	9
1 – Minor "scuffing" damage	9
2 – Scuffing and relatively minor deformation	11
3 - Major deformation but still intact	26
4 – Highly deformed and/or ruptured	25
Total	80

IN DATABASE



CWRU Feral Battery Research Project
Feral Battery Identification Report

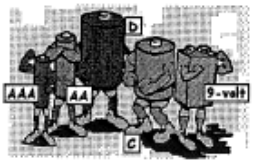
Site Location: Holyoke/Belmore to Lee **Date** 6/25/08

Team Identification: A. Jennings, P. Manglona, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel, 2. Steel/zinc, 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Duracell Copper Top	AA	1	4	4
2	Duracell Copper Top	AA	1	3	2
3	Duracell Copper Top	AA	1	3	1
4	Duracell Copper Top	AA	1	3	1
5	Duracell Copper Top	AA	1	0	0
6	Duracell Ultra	AA	1	1	1
7	Duracell Copper Top	AAA	1	1	0
8	Duracell Copper Top	AAA	1	3	2
9	Duracell Copper Top	AAA	1	1	3
10	Duracell Copper Top	AAA	1	1	2
11	Duracell Copper Top	AAA	1	4	4
12	Energizer	AA	1	3	1
13	Energizer	AA	1	3	2
14	Energizer	AA	1	3	2
15	Energizer	AA	1	2	3
16	Energizer	AA	1	1	3
17	Energizer	AA	1	3	3
18	Energizer	AA	1	1	4
19	Energizer (Power check)	AA	1	3	3
20	Energizer e^2 titanium	AA	1	3	3

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



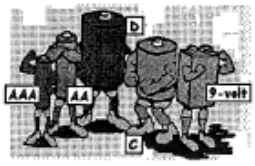
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
21	Energizer Lithium	AA	1	3	1
22	Energizer	AAA	1	3	1
23	Energizer	AAA	1	3	1
24	Energizer	AAA	1	1	3
25	Energizer	AAA	1	1	3
26	Energizer	AAA	1	2	3
27	Eveready Gold	AA	1	3	3
28	Eveready Gold	AAA	1	3	2
29	Eveready Super Heavy Duty	AA	2	0	0
30	Panasonic Super Heavy Duty	AA	2	4	4
31	Panasonic Alkaline for Digital	AA	1	3	2
32	Samsung Pleomax	AA	1	0	1
33	Samsung Pleomax	AA	1	1	3
34	Samsung Pleomax	AA	1	1	3
35	Eveready	AAA	2	3	3
36	CVS Alkaline	AA	1	2	4
37	~~Magnavox~~ Max-ell	AAA	1	3	3
38	Sunbeam Super Heavy Duty	AA	1	2	3
39	Universal Electronics	AA	2	4	4
40	DG Ultra Heavy Duty	AA	3	4	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
41	Digital Cell	AAA	3	3	1
42	Garrity Super Heavy Duty	D	2	3	4
43	Unknown	button cell	unknown	1	0
44	Unknown	AA	1	2	3
45	Duracell	AA	1	3	3
46	~~Unknown - phone batt.~~				
47					
48					
49					
50					
51					
52					
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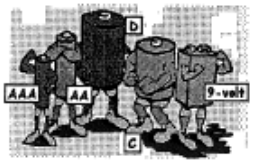
54					
55					
56					
57					
58					
59					
60					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	12
Energizer	15
Eveready	4
Rayovac	0
Panasonic	2
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	1
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	9
Unknown (can't be determined from label)	2
Total	45

Summary of Battery Cell Size

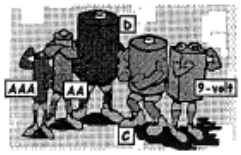
Battery Size	Number
AA	29
AAA	14
D	1
C	0
9V	0
Other	1
Total	45

Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	37
Type 2 – Zinc barrel with steel sheath	5
Type 3 – Zinc barrel with paper/plastic label	2
Type 2-3 (zinc barrel of uncertain origin)	0
Other	1
Total	45

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	4
1 – Minor "scuffing" damage	9
2 – Scuffing and relatively minor deformation	7
3 - Major deformation but still intact	17
4 – Highly deformed and/or ruptured	8
Total	45



IN DATABASE

CWRU Feral Battery Research Project
Feral Battery Identification Report

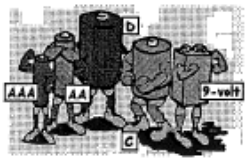
Site Location: Euclid Ave. Lee to Strathmore +FD **Date** 6/25/08

Team Identification: A. Jennings, P. Manglona, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel 2. Steel/zinc 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Duracell Copper Top	AA	1	3	2
2	Duracell Copper Top	AA	1	0	0
3	Duracell Copper Top	AA	1	1	3
4	Duracell Copper Top	AA	1	1	0
5	Duracell Copper Top	AA	1	1	0
6	Duracell Copper Top	AA	1	1	2
7	Duracell Copper Top	AA	1	2	2
8	Duracell Copper Top	AA	1	3	2
9	Duracell Copper Top	AA	1	1	3
10	Duracell Copper Top	AA	1	2	2
11	Duracell Copper Top	AA	1	2	1
12	Duracell Copper Top	AAA	1	1	3
13	Duracell Copper Top	AAA	1	4	4
14	Duracell Copper Top	AAA	1	2	3
15	Duracell Copper Top	AA	1	4	4
16	Duracell Power Pix	AAA	1	3	2
17	Eveready Gold	AA	1	1	3
18	Eveready Gold	AA	1	1	3
19	Eveready Gold	AA	1	1	3
20	Panasonic Super Heavy Duty	AA	2	3	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



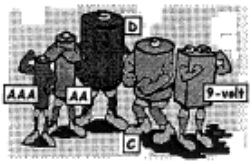
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
21	Energizer	AA	1	3	1
22	Energizer	AA	1	1	4
23	Energizer	AA	1	1	4
24	Energizer	AA	1	2	3
25	Energizer	AA	1	1	3
26	Energizer	AA	1	1	4
27	Energizer	AAA	1	1	3
28	Energizer Industrial	AAA	1	2	3
29	Rayovac	AA	1	2	2
30	Q-Force	AA	3	0	1
31	Walgreens Heavy Duty	AA	2	8	1
32	Walgreens Heavy Duty	AAA	2	3	4
33	Walgreens Supercell	AAA	2	2	3
34	unknown	AA	1	2	3
35	unknown	AA	Unknown	4	4
36	unknown	AA	1	4	4
37	unknown	AA	1	3	3
38	unknown	AA	1	2	3
39	unknown	AA	unknown	4	4
40					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	16
Energizer	8
Eveready	3
Rayovac	1
Panasonic	1
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	3
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	1
Unknown (can't be determined from label)	6
Total	39

Summary of Battery Cell Size

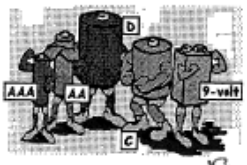
Battery Size	Number
AA	31
AAA	8
D	0
C	0
9V	0
Other	0
Total	39

Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	32
Type 2 – Zinc barrel with steel sheath	4
Type 3 – Zinc barrel with paper/plastic label	1
Type 2-3 (zinc barrel of uncertain origin)	0
Other	2
Total	39

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	3
1 – Minor "scuffing" damage	4
2 – Scuffing and relatively minor deformation	7
3 - Major deformation but still intact	15
4 – Highly deformed and/or ruptured	10
Total	39



CWRU Feral Battery Research Project
Feral Battery Identification Report

NO DATABASE

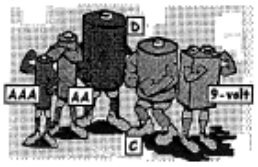
Site Location: Broadway Ave · Aetna Rd · to Blanche **Date** 7/1/08

Team Identification: A. Jennings, P. Manglona, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
1	Duracell	AAA	1	1	2
2	Duracell	AAA	1	1	2
3	Duracell	AAA	1	1	2
4	Duracell	AA	1	2	1
5	Energizer Industrial	AA	1	2	3
6	Energizer	AA	1	0	1
7	Energizer	AA	1	0	1
8	Energizer	AA	1	1	1
9	Energizer	AA	1	1	3
10	Energrizer	AAA	1	1	0
11	Energrizer	AAA	1	2	3
12	Eveready Gold	AA	1	1	2
13	Eveready Gold	AA	1	1	1
14	Eveready Gold	AAA	1	1	1
15	Eveready Super Heavy Duty	AA	2	3	1
16	Eveready Super Heavy Duty	AA	2	4	4
17	Eveready Gold	AAA	1	3	3
18	Panasonic Superheavy Duty	AA	2	4	3
19	Panasonic Super Heavy Duty	AA	2	2	4
20	Panasonic Super Heavy Duty	AA	2	3	1

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



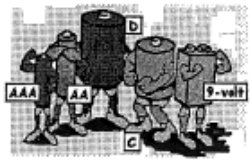
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel 2. Steel/zinc 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
21	Panasonic Super Heavy Duty	AA	2	3	3
22	Panasonic Super Heavy Duty	AA	2	4	4
23	Panasonic Super Heavy Duty	AA	2	4	4
24	Panasonic Super Heavy Duty	AAA	2	1	4
25	Panasonic Super Heavy Duty	AAA	2	2	1
26	Panasonic Super Heavy Duty	AAA	2	4	4
27	Q-Force Super Extra Heavy Duty	AA	3	4	2
28	Q-Force Heavy Duty	AA	3	0	2
29	Q-Force Heavy Duty	AA	3	0	3
30	Q-Force Heavy Duty	AAA	3	0	4
31	Q-Force Heavy Duty	AAA	3	0	2
32	Q-Force Heavy Duty	AAA	3	4	4
33	Radio Shack Enercell	AA	1	1	2
34	Sony	AA	1	3	4
35	GP Alkaline	AAA	1	2	3
36	Yong Li Extra Heavy Duty	AA	3	1	~~4~~ 3
37	Dorcy Mastercell	D	? (1)	~~2~~ 3	2
38	Supergard	AAA	1	3	1
39	Fastenal	9V	unknown	0	0
40	Unknown	AA	1	3	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



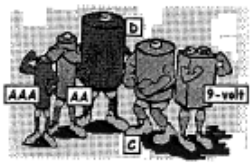
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
41	unknown	AA	1	2	4
42	unknown	AAA	1	4	4
43	unknown	AA	1	0	4
44	unknown	AA	1	4	4
45	unknown	AAA	1	4	4
46	unknown	AAA	1	3	4
47	unknown	AA	1	3	4
48	unknown	AAA	1	3 4	4
49	unknown	AA	2-3	4	4
50	unknown	AAA	1	1	2
51	Renata (3V)	3V	unknown	0	0
52					
53					
54					
55					
56					
57					
58					
59					
60					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	4
Energizer	7
Eveready	6
Rayovac	0
Panasonic	9
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	0
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	1
Misc. International Labels (Novel, Okkaido, ...)	13
Unknown (can't be determined from label)	11
Total	51

Summary of Battery Cell Size

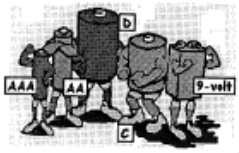
Battery Size	Number
AA	28
AAA	20
D	1
C	0
9V	1
Other	1
Total	51

Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	30
Type 2 – Zinc barrel with steel sheath	11
Type 3 – Zinc barrel with paper/plastic label	7
Type 2-3 (zinc barrel of uncertain origin)	1
Other	2
Total	51

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	3
1 – Minor "scuffing" damage	10
2 – Scuffing and relatively minor deformation	10
3 - Major deformation but still intact	9
4 – Highly deformed and/or ruptured	19
Total	51



CWRU Feral Battery Research Project
Feral Battery Identification Report

IN DATABASE

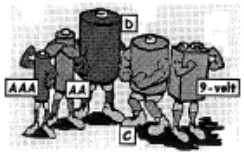
Site Location: 55th St. **Date** 7/1/08

Team Identification: A. Jennings, P. Mangluna, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel 2. Steel/zinc 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Energizer	AA	1	1	2
2	Energizer	AA	1	1	1
3	Energizer	AA	1	1	1
4	Energizer	AA	1	1	1
5	Energizer	AA	1	1	3
6	Energizer	AA	1	1	3
7	Energizer	AA	1	2	3
8	Energizer e² Titanium	AA	1	1	3
9	Energizer	AA	1	1	3
10	Energizer	AAA	1	2	1
11	Energizer	AAA	1	2	1
12	Duracell	AA	1	3	2
13	Duracell	AA	1	2	1
14	Duracell	AA	1	3	1
15	Duracell	AA	1	2	3 4
16	Duracell Ultra	AA	1	3	4
17	Panasonic Super Heavy Duty	AAA	2	2	1
18	Rayovac	AAA	1	2	4
19	Zhaoneng Super Heavy Duty	AAA	3	0	3
20	Ultralast Alkaline	AA	1	2	1

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



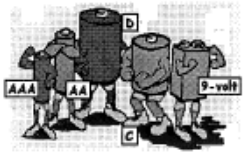
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
21	Rite Aid Alkaline	AAA	1	3	1
22	Unknown	AAA	1	3	3
23	unknown	AA	1	3	3
24	unknown	AA	1	4	4
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	5
Energizer	11
Eveready	0
Rayovac	1
Panasonic	1
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	1
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	2
Unknown (can't be determined from label)	3
Total	24

Summary of Battery Cell Size

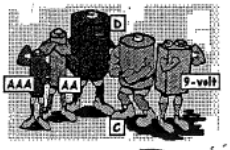
Battery Size	Number
AA	17
AAA	7
D	0
C	0
9V	0
Other	0
Total	24

Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	22
Type 2 – Zinc barrel with steel sheath	1
Type 3 – Zinc barrel with paper/plastic label	1
Type 2-3 (zinc barrel of uncertain origin)	0
Other	0
Total	24

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	0
1 – Minor "scuffing" damage	10
2 – Scuffing and relatively minor deformation	2
3 - Major deformation but still intact	8
4 – Highly deformed and/or ruptured	4
Total	24



CWRU Feral Battery Research Project
Feral Battery Identification Report

IN DATABASE

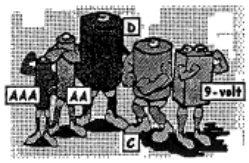
Site Location: Euclid Ave. Lee to Strathmore + F.D **Date** 7/24/08

Team Identification: A. Jennings, P. Manglona, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
1	Duracell	AA	1	2	2
2	Duracell	AA	1	1	2
3	Duracell	AA	1	2	2
4	Duracell	AA	1	2	2
5	Duracell	AA	1	2	3
6	Duracell	AA	1	1	3
7	Duracell	AA	1	1	3
8	Duracell	AA	1	1	3
9	Duracell	AAA	1	0	3
10	Duracell	AAA	1	3	3
11	Duracell Procell	AA	1	1	3
12	Energizer	AA	1	1	2
13	Energizer	AA	1	0	2
14	Energizer	AA	1	2	3
15	Energizer	AA	1	1	3
16	Energizer	AAA	1	1	3
17	Eveready	AA	2	1	1
18	Rayovac	AA	1	3	2
19					
20					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	11
Energizer	5
Eveready	1
Rayovac	1
Panasonic	0
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	0
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	0
Unknown (can't be determined from label)	0
Total	18

Summary of Battery Cell Size

Battery Size	Number
AA	15
AAA	3
D	0
C	0
9V	0
Other	0
Total	18

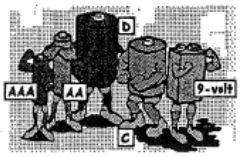
Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	17
Type 2 – Zinc barrel with steel sheath	1
Type 3 – Zinc barrel with paper/plastic label	0
Type 2-3 (zinc barrel of uncertain origin)	0
Other	0
Total	18

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	0
1 – Minor "scuffing" damage	1
2 – Scuffing and relatively minor deformation	7
3 - Major deformation but still intact	10
4 – Highly deformed and/or ruptured	0
Total	18

IN DATABASE



CWRU Feral Battery Research Project
Feral Battery Identification Report

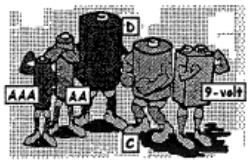
Site Location: Euclid Ave. Holyoke/Belmone to Lee **Date** 7/24/08

Team Identification: A. Jennings, P. Manglona, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel, 2. Steel/zinc, 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Energizer	AA	1	1	1
2	Energizer	AA	1	0	1
3	Energizer	AA	1	2	1
4	Energizer	AA	1	0	0
5	Energizer	AA	1	1	3
6	Energizer	AA	1	3	3
7	Energizer Industrial	AAA	1	1	3
8	Energizer Industrial	AAA	1	1	3
9	Energizer	AAA	1	2	3
10	~~Energizer~~ Eveready	AA	2	1	2
11	Eveready	AA	2	0	3
12	Eveready Gold	AA	1	1	3
13	Eveready Gold	AAA	1	1	3
14	Eveready Gold	AAA	1	3	3
15	Duracell Copper Top	AA	1	2	2
16	Duracell Copper Top	AA	1	1	1
17	Duracell Copper Top	AA	1	1	1
18	Duracell Copper Top	AA	1	2	1
19	Duracell Copper Top	AA	1	1	3
20	Duracell Procell	AA	1	1	3

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



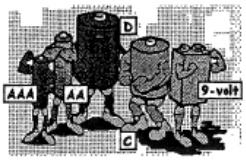
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
21	Panasonic Super Heavy Duty	AAA	2	1	4
22	Phaser	AA	1	1	1
23	Phaser	AA	1	1	1
24	Walgreens Ultra Alkaline	AAA	1	1	3
25	Walgreens Ultra Alkaline	AAA	1	1	3
26	Walgreens Ultra Alkaline	AAA	1	2	2
27	Walgreens Heavy Duty Powercell	AA	2	2	3
28	Maxell Alkaline Ace	AAA	1	0	3
29	Powermax Ultra Longlasting	AAA	1	1	3
30	DG Xtra Heavy Duty	AA	3	4	4
31	DG xtra Heavy Duty	AA	3	2	2
32	unknown	AA	2	4	3
33	unknown	AA	1	4	4
34	unknown	AA	2	4	3
35	unknown	AA	1	3	3
36	unknown	AA	1	2	4
37	unknown	AA	2	2	4
38	unknown	AA	2/3	2	4
39	unknown	AAA	3	3	4
40	unknown	AA	2/3	4	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



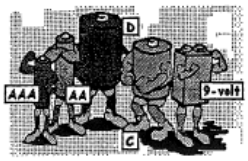
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
41	unknown	AA	1	4	4
42	unknown	AA	1	4	4
43					
44					
45					
46					
47					
48					
49					
50					
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	6
Energizer	9
Eveready	5
Rayovac	0
Panasonic	1
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	4
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	2
Misc. International Labels (Novel, Okkaido, ...)	4
Unknown (can't be determined from label)	11
Total	42

Summary of Battery Cell Size

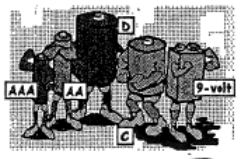
Battery Size	Number
AA	30
AAA	12
D	0
C	0
9V	0
Other	0
Total	42

Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	30
Type 2 – Zinc barrel with steel sheath	7
Type 3 – Zinc barrel with paper/plastic label	3
Type 2-3 (zinc barrel of uncertain origin)	2
Other	0
Total	42

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	1
1 – Minor "scuffing" damage	8
2 – Scuffing and relatively minor deformation	4
3 - Major deformation but still intact	19
4 – Highly deformed and/or ruptured	10
Total	42



CWRU Feral Battery Research Project
Feral Battery Identification Report

IN DATABASE

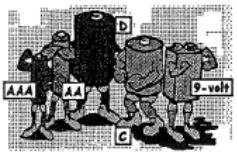
Site Location: EUCLID & SUPERIOR **Date** 7/23/08

Team Identification: A. Jennings, P. Manglona, M. Miller

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1: Steel, 2: Steel/zinc, 3: Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Duracell Copper Top	AA	1	0	1
2	Duracell Copper Top	AA	1	0	1
3	Duracell Copper Top	AA	1	0	1
4	Duracell Copper Top	AA	1	1	1
5	Duracell Copper Top	AA	1	0	1
6	Duracell Copper Top	AA	1	1	3
7	Duracell Copper Top	AA	1	1	3
8	Duracell Copper Top	AA	1	1	3
9	Duracell Copper Top	AA	1	1	4
10	Duracell Copper Top	AA	1	2	3
11	Duracell Copper Top	AA	1	1	3
12	Duracell Copper Top	AAA	1	2	3
13	Duracell Copper Top	AAA	1	1	3
14	Duracell Copper Top	AAA	1	1	4
15	Duracell Copper Top	AAA	1	2	1
16	Duracell Ultra	AAA	1	1	3
17	Duracell Ultra	AA	1	3	2
18	Duracell Ultra	AA	1	1	1
19	Energizer	AA	1	1	3
20	Energizer	AA	1	1	3

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



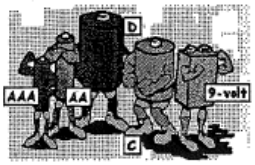
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	 Physical Damage (0 - 4)
21	Energizer C	AA	1	1	2
22	Energizer	AAA	1	0	0
23	Eveready Gold	AA	1	0	0
24	Eveready Gold	AA	1	0	0
25	Eveready Gold	AA	1	0	3
26	Eveready Gold	AA	1	3	4
27	Eveready Gold	AA	1	3	3
28	Eveready Gold	AAA	1	0	1
29	Eveready Gold	AAA	1	1	0
30	Eveready Super Heavy Duty	AA	2	4	4
31	Eveready Super Heavy Duty	AA	2	4	4
32	Eveready	AAA	2	1	1
33	Panasonic Super Heavy Duty	AA	2	2	1
34	Panasonic Super Heavy Duty	AA	2	0	3
35	Panasonic Super Heavy Duty	AA	2	1	3
36	Panasonic Super Heavy Duty	AA	2	0	4
37	Panasonic Super Heavy Duty	AAA	2	1	0
38	Panasonic Plus	AA	1	0	3
39	Ultralast	AAA	1	0	3
40	Goldcell Super High Power	AA	3	3	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



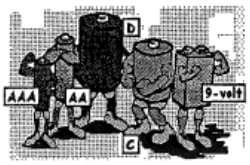
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
41	Energy Super Plus Alkaline	AAA	1	0	1
42	Q- Force Heavy Duty	AAA	3	0	4
43	X tra Heavy Duty	AA	3	0	3
44	Large Super Heavy Duty	AAA	3	2	1
45	Walgreens Ultra Alkaline	AA	1	4	4
46	Unknown	AA	1	2	3
47	Unknown	AA	1	2	3
48	Unknown	AA	1	2	3
49	Unknown	AA	1	2	4
50	Unknown	AA	1	2	3
51	Unknown	AA	1	3	4
52	Unknown	AA	1	4	4
53	Unknown	AAA	1	0	4
54	~~unknown~~ unknown	AAA	1	1	4
55	buttoncell			1	1
56	cell phone battery			0	2
57					
58					
59					
60					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	18
Energizer	4
Eveready	10
Rayovac	0
Panasonic	6
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	1
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	0
Misc. International Labels (Novel, Okkaido, ...)	6
Unknown (can't be determined from label)	11
Total	56

Summary of Battery Cell Size

Battery Size	Number
AA	38
AAA	16
D	0
C	0
9V	0
Other	2
Total	56

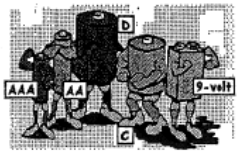
Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	42
Type 2 – Zinc barrel with steel sheath	8
Type 3 – Zinc barrel with paper/plastic label	4
Type 2-3 (zinc barrel of uncertain origin)	0
Other	2
Total	56

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	5
1 – Minor "scuffing" damage	12
2 – Scuffing and relatively minor deformation	4
3 - Major deformation but still intact	21
4 – Highly deformed and/or ruptured	14
Total	56

(in DATABASE)



CWRU Feral Battery Research Project
Feral Battery Identification Report

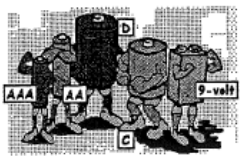
Site Location: Broadway Ave. Aetna Rd. to Blance **Date** 7/31/08

Team Identification: A. Jennings, P. Manglona, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel, 2. Steel/zinc, 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Duracell Copper Top	AA	1	0	1
2	Duracell Copper Top	AA	1	0	1
3	Duracell Copper Top	AA	1	0	1
4	Duracell Copper Top Plus	AA	1	0	1
5	Duracell Copper Top	AA	1	1	2
6	Duracell Copper Top	AA	1	2	3
7	Duracell Ultra	AAA	1	4	4
8	Energizer	AA	1	1	1
9	Energizer	AA	1	1	1
10	Energizer	AA	1	0	0
11	Energizer Lithium Photo	3.0 V	misc.	0	1
12	Eveready Super Heavy Duty	AA	2	1	4
13	Eveready Super Heavy Duty	AA	2	3	4
14	Eveready Super Heavy Duty	AA	2	3	4
15	Eveready Super Heavy Duty	AA	2	3	4
16	Eveready Super Heavy Duty	AAA	2	3	4
17	Panasonic Super Heavy Duty	AA	2	1	3
18	Panasonic Super Heavy Duty	AA	2	0	4
19	Panasonic Super Heavy Duty	AA	2	4	4
20	Panasonic Super Heavy Duty	AA	2	2	3

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



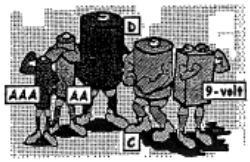
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size AA, AAA C, D, 9V	Type 1. Steel 2. Steel/zinc 3. Zinc	Deterioration Corrosion Condition (0 - 4)	Deterioration Physical Damage (0 - 4)
21	Walgreens Ultra Alkaline	AA	1	0	0
22	Walgreens Ultra Alkaline	AAA	1	0	2
23	Ultralast Alkaline	AA	1	0	3
24	CVS Alkaline	AA	1	0	0
25	Polaroid	AAA	1	0	0
26	Samsung Pleomax	AAA	2	1	1
27	Unknown	AA	1	3	2
28	Unknown	AA	1	0	4
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	7
Energizer	4
Eveready	5
Rayovac	0
Panasonic	4
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	3
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	1
Misc. International Labels (Novel, Okkaido, ...)	2
Unknown (can't be determined from label)	2
Total	28

Summary of Battery Cell Size

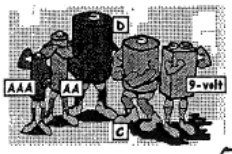
Battery Size	Number
AA	22
AAA	5
D	0
C	0
9V	0
Other	1
Total	28

Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	17
Type 2 – Zinc barrel with steel sheath	10
Type 3 – Zinc barrel with paper/plastic label	0
Type 2-3 (zinc barrel of uncertain origin)	0
Other	1
Total	28

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	4
1 – Minor "scuffing" damage	8
2 – Scuffing and relatively minor deformation	3
3 - Major deformation but still intact	4
4 – Highly deformed and/or ruptured	9
Total	28



CWRU Feral Battery Research Project
Feral Battery Identification Report

IN DATABASE

7/31/08

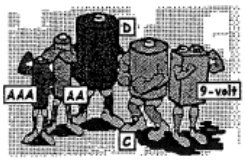
Site Location: 55th Street **Date** ~~7/31/08~~

Team Identification: A. Jennings, P. Manglona, M. Miller, M. Gayle

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1: Steel, 2: Steel/zinc, 3: Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
1	Duracell Copper Top	AA	1	0	1
2	Duracell Copper Top	AA	1	0	0
3	Duracell Copper Top	AA	1	1	1
4	Duracell Copper Top	AA	1	4	4
5	Duracell Copper Top	AAA	1	1	3
6	Energizer	AA	1	0	0
7	Energizer	AA	1	1	1
8	Energizer	AA	1	0	3
9	Energizer	AA	1	0	2
10	Energizer	AA	1	0	2
11	Energizer	AA	1	0	2
12	Energizer	AA	1	0	0
13	Energizer	AA	1	1	0
14	Energizer	AA	1	1	1
15	Energizer	AAA	1	1	3
16	Eveready Super Heavy Duty	AA	2	0	4
17	Eveready Super Heavy Duty	AA	2	4	4
18	Eveready Super Heavy Duty	AA	2	3	3
19	Panasonic Super Heavy Duty	AA	2	2	0
20	Panasonic Super Heavy Duty	AA	2	1	4

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



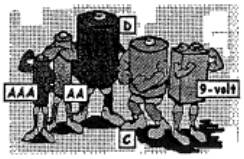
CWRU Feral Battery Research Project
Feral Battery Identification Report

(continued)

Please record as much information as possible about each feral battery found.

	Manufacturer (Make & Model)	Size (AA, AAA, C, D, 9V)	Type (1. Steel, 2. Steel/zinc, 3. Zinc)	Deterioration: Corrosion Condition (0 - 4)	Deterioration: Physical Damage (0 - 4)
21	Panasonic Super Heavy Duty	AAA	2	1	4
22	Polaroid	AA	2	0	4
23	Polaroid	AA	2	0	4
24	Philips Powerlife	AA	1	0	1
25	Rayovac	AA	1	2	3
26	Xtra Heavy Duty	AA	2	3	2
27	Ultralast Alkaline	AA	1	2	2
28	Unknown	AAA	1	1	4
29	Unknown	AAA	2/3	4	4
30	unknown Lithium batt			0	3
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					

Notes: (Record anything unusual about batteries by table row number. Identify pictures if available):



CWRU Feral Battery Research Project
Feral Battery Identification Report

Survey Data Summary

Summary of Battery Manufacturer

Battery Manufacturer/Type	Number
Duracell	5
Energizer	10
Eveready	3
Rayovac	1
Panasonic	3
Misc. U.S. Store Private Label (CVS, Rite Aid, Walgreens, Giant Eagle, . .)	0
Misc. U.S. Company Brands (Radio Shack, Dorcy, Kodak, Poloroid, ...)	2
Misc. International Labels (Novel, Okkaido, ...)	3
Unknown (can't be determined from label)	3
Total	30

Summary of Battery Cell Size

Battery Size	Number
AA	24
AAA	5
D	0
C	0
9V	0
Other	1
Total	30

Summary of Battery Barrel Type

Battery Construction	Number
Type 1 – Steel barrel with paper/plastic label	19
Type 2 – Zinc barrel with steel sheath	9
Type 3 – Zinc barrel with paper/plastic label	0
Type 2-3 (zinc barrel of uncertain origin)	1
Other	1
Total	30

Summary of Battery Physical Condition

Battery Physical Condition	Number
0 – Like new	5
1 – Minor "scuffing" damage	5
2 – Scuffing and relatively minor deformation	5
3 - Major deformation but still intact	6
4 – Highly deformed and/or ruptured	9
Total	30

Appendix B

Feral Battery Litter Rates

Paul Manglona

Summer 2008

Feral Batter Litter Rates

Paul Manglona

Civil Engineering Department

Case Western Reserve University

Cleveland, OH 44106

pxm97@case.edu

Abstract

The environmental harm caused by consumer battery litter remains unheard of to many individuals. Because the three main types of consumer batteries (Alkaline, Zinc Carbon, and Zinc Chloride) all contain heavy metals, most notably Zinc, Feral Batteries have great potential to pollute waterways in times of snowmelt or heavy rainfall via storm drains. Of the five sites surveyed during this research project, three (Euclid & Superior, Euclid- Holyoke to Lee, and Euclid- Lee to Strathmore) had trend lines indicating an increase in batter litter. The other two sites surveyed (Broadway and East 55^{th}) had trend lines indicating a decrease. Despite the trend lines' indications, none of the lines fitted the data well with the best fit having R^2= 0.5119. More data is needed in order to make a more accurate analysis as to whether or not battery litter rates are decreasing. In the near future, as more people transition from portable electronics with disposable batteries to rechargeable batteries, a decrease in batter litter is expected.

Introduction

The term "Feral Batteries" arises from the fact that these consumer batteries are no longer domesticated, and are now found outdoors where they are exposed to the elements. The exposure of batteries to the weather, pedestrians, and automobile traffic will certainly result in the battery rupturing either through corrosion of physical damage.

Because of the portable nature of consumer batteries, widespread use of portable electronics, and prevalent littering; many batteries have found their way into streets and parking lots. The most common sizes of batteries found are referred to as the “Big 5” and include AA, AAA, D, C, and 9V. The Big 5 were found in their highest concentrations at areas of high pedestrian traffic, most notably at bus stops and parking lots near stores; places where people can sit down and replace used batteries or replace used batteries after purchasing new ones.

Majority of littered consumer batteries, fall into one of three categories determined by their power chemistries; these include Alkaline, Zinc Carbon, and Zinc Chloride. Each of these power chemistries has a corresponding barrel. The barrel is the physical structure that contains the actual components of the battery. The respective barrels of Alkaline, Zinc Carbon, and Zinc Chloride batteries are steel, steel sheath, and Zinc. The steel barrel of an alkaline battery is essentially a steel can encapsulating the anode made of Zinc with Potassium Chloride serving as the electrolyte. Zinc Carbon batteries utilize the Zinc barrel which also serves as the cell’s anode. Lastly, Zinc Chloride batteries are basically Zinc Carbon batteries with an electrolyte consisting of Zinc Chloride and water, wrapped around with a steal sheath.

Many people are oblivious to the potential environmental harm of battery litter. When batteries become feral, it does not take long for the barrels to corrode and dispel their internal components, nor does it take much to physically rupture the barrels. Feral batteries are subjected to rain, snow, salt, and pedestrian and automobile traffic. As evident in the previous paragraph, all three types of batteries contain heavy metals, and once a battery is ruptured its contents are allowed to leak. Eventually, the heavy metals make their way into storm drains, after heavy rainfall, and then into natural waterways. This process is called Non Point Source (NPS) Pollution, because the source of the pollution cannot be identified. The U.S. Environmental

Protection Agency describes NPS pollution as being "caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water."

In part on an ongoing research project conducted by, Case Western Reserve University's Civil Engineering professor, Aaron Jennings, battery surveys were conducted in the months of May, June, and July of 2008 to determine whether or not battery litter rates have decreased over the past few years, ranging from two to six years. A battery survey, in essence, is the act of collecting littered batteries from specific sites. A total of 15 surveys were conducted during the three month period. The sites surveyed, are entitled after the streets we collected batteries from, and are Broadway, East 55th, Euclid & Superior, Euclid- Holyoke to Lee, and Euclid-Lee to Strathmore. The sites were strategically surveyed during the summer months when pedestrian traffic was heaviest. Also, during the winter months of Cleveland, surveying proved to be difficult and inaccurate due to heavy snowfall.

As technology advances, and more portable electronic devices utilize rechargeable batteries, we expect to see a decline in battery litter rates. However, due to the cheapness of Zinc Carbon batteries from China ($1.00 for 16 AA batteries), our expectations may not hold true.

Method

Battery surveys were conducted in teams of four. On the sidewalk, we split into two pairs with one pair leading the way and the other pair following closely behind to make sure no batteries were missed. With the lead members walking alongside each other, one individual

scoured along the curb and the road while the other searched the sidewalk. In parking lots, the team splits up and searched particular zones.

Each team member was equipped with a powerful magnet attached to a pole, a bag to hold collected batteries, and a screwdriver to remove any batteries that maybe lodged into the ground. After conducting the survey, a count is made and the batteries are brought back to campus where the data is processed. The brand, size, type of barrel, physical, and chemical deterioration is then recorded for every individual battery. To assist in the identification of batteries that have worn out labels or are partially labeled, a battery catalog consisting of more than 300 batteries, composed by Prof. Aaron Jennings and research assistants is ready at hand. The battery catalog contains photos, physical descriptions, and weight measurements. A sample of some batteries I cataloged is available in the Appendix. See also Figure 1 for an example of when the catalog would be useful. The data collected for each specimen is then placed in a database along with all the previous surveys.

For each of the five sites, three surveys were conducted. In Figures 2 through 6, the first survey of each year has been omitted to eliminate the inconsistency of not having conducted surveys during winter months. The other two surveys would then be a true testament to the amount of battery litter per month.

Analysis

When determining the physical damage and corrosion condition of each specimen, a rating of 0-4 is assigned to each type of deterioration. See Table 1.

Rating	Physical Damage	Corrosion Condition
0	No damage. Brand new.	No corrosion. Brand new.
1	Minor cosmetic damages, i.e. scratches	Small and isolated spots of corrosion.
2	Minor indentations.	Corrosion on at least one terminal, and covering most of the barrel
3	Major deformations, but barrel is still intact	Corrosion covering entire barrel, but barrel is not compromised.
4	Major deformations, barrel is ruptured.	Cracks or ruptures are apparent on the barrel

Table 1: Description of Ratings

Figure 1: Battery Exhibiting Physical Damage Rating of 3 and Corrosion Condition rating of 2.

Figures 2-6 are plots of the number of batteries littered versus number of months, with the first survey of each year taken out. A linear fit was added to the plot to show the current trend of battery litter. While Broadway and East 55th had trend lines indicating a decrease in battery litter, the remaining three Euclid sites all had trend lines indicating the opposite. See Figures 2-6. The trend lines however, did not fit the data well with R^2 values ranging from 0.0232, for Lee to Strathmore, to 0.5119 for Euclid and Superior. Figures 7-11 are column charts representing every survey conducted for the five sites.

Because of the randomness of battery litter, the variability is too great to make an accurate judgment as to whether or not battery litter rates were decreasing; more surveys and data are needed.

Summary and Conclusion

Feral batteries threaten our environment, especially out waterways, when they are ruptured and release heavy metals. Because of the power chemistries of consumer batteries, all three types of batteries discussed in this paper contain Zinc, a heavy metal with high aquatic toxicity. According to the U.S. National Water Quality Criteria, Zinc has Fresh Water Quality Criteria Maximum Peak at 120.0 µg/L. Because of the areas of highest concentrations of battery litter (bus stops and parking lots) are situated near storm drains, it is likely that the released heavy metals make their way into our waterways during times of heavy rainfall or snowmelt, via storm drains.

A decrease in battery litter is expected in the next few years as more people transition from disposable to rechargeable batteries. But with the cheap price of Zinc Carbon batteries it may take a while before a major decrease in battery litter is apparent.

Of the all batteries found in the summer months of 2008, majority were of the Big 5. During surveys the Feral Battery Research team not only picked up batteries but also picked up, lug nuts, coins, and cell phone batteries. Places where most samples were collected were bus stops and parking lots of stores that sold batteries. The ratings of batteries picked up ranged from 0 to 4 for both physical damage and corrosion condition. Some batteries were even found to have a physical damage rating of 4 and corrosion condition rating of 0, meaning that they were ran over by an automobile. It was very rare that a sample had the opposite, a corrosion condition rating of 4 and physical damage of 0. The only way this would be possible is if the batter was littered in a place of little to no pedestrian and/or automobile traffic. See Table 1 for a description of the ratings used.

Acknowledgements

I would like to thank Dr. Aaron Jennings for the opportunity to participate in this research project, and for his help and support. I would also like to acknowledge my fellow research team members, Daniel Hill, Mikhail Miller, and Maurice Gayle for their assistance in conducting surveys.

Rerferences

Eveready Battery Co. Inc. (2001). "Eveready Carbon Zinc (Zn/MnO^2) Application Manual." <http://data.energizer.com/PDFs/carbonzinc_appman.pdf> [8/07/08].

Kegley, S.E., Hill, B.R., Orme S., Choi A.H., *PAN Pesticide Database,* Pesticide Action Network, North America (San Francisco, CA, 2008), http:www.pesticideinfo.org [8/05/08]

U.S. EPA (Environmental Protection Agency) (2008). "Polluted Runoff (Nonpoint Source Pollution) (3/07/08)." <http://epa.gov/owow/nps/qa.html > [08/05/08]

List of Tables

List of Figures

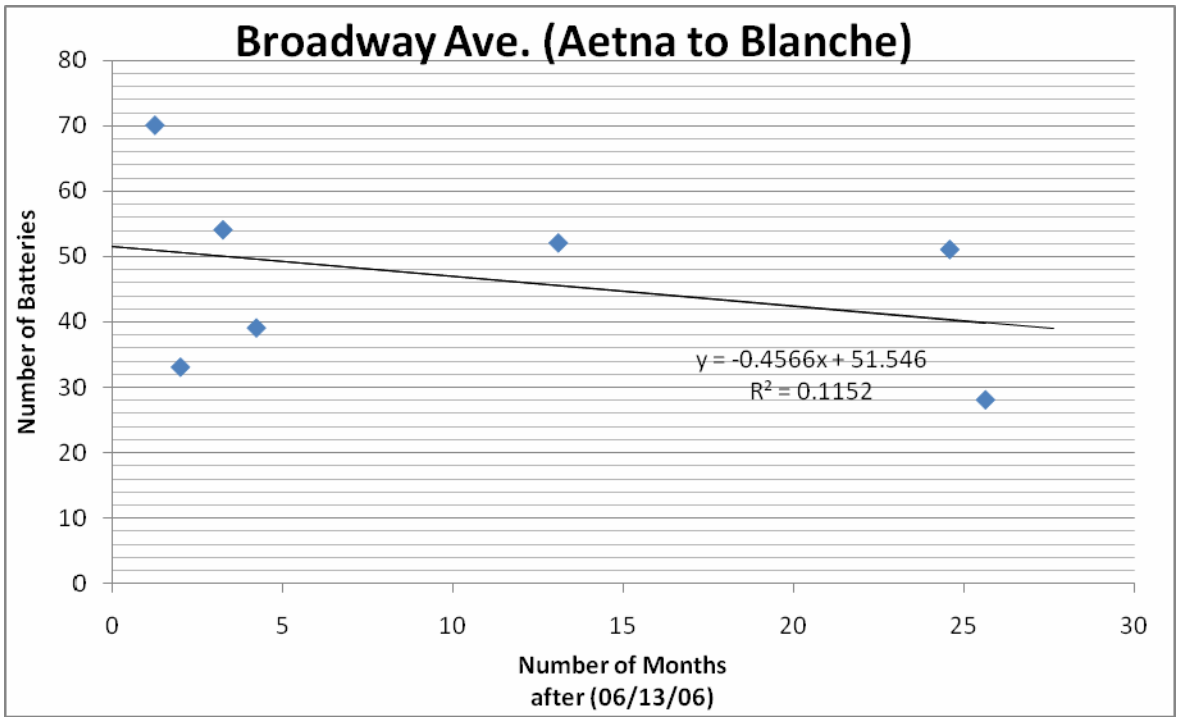


Figure 2: Broadway Site Survey results. (First survey of each year has been omitted.)

Figure 3: East 55th Site Survery results. (First survey of each year has been omitted.)

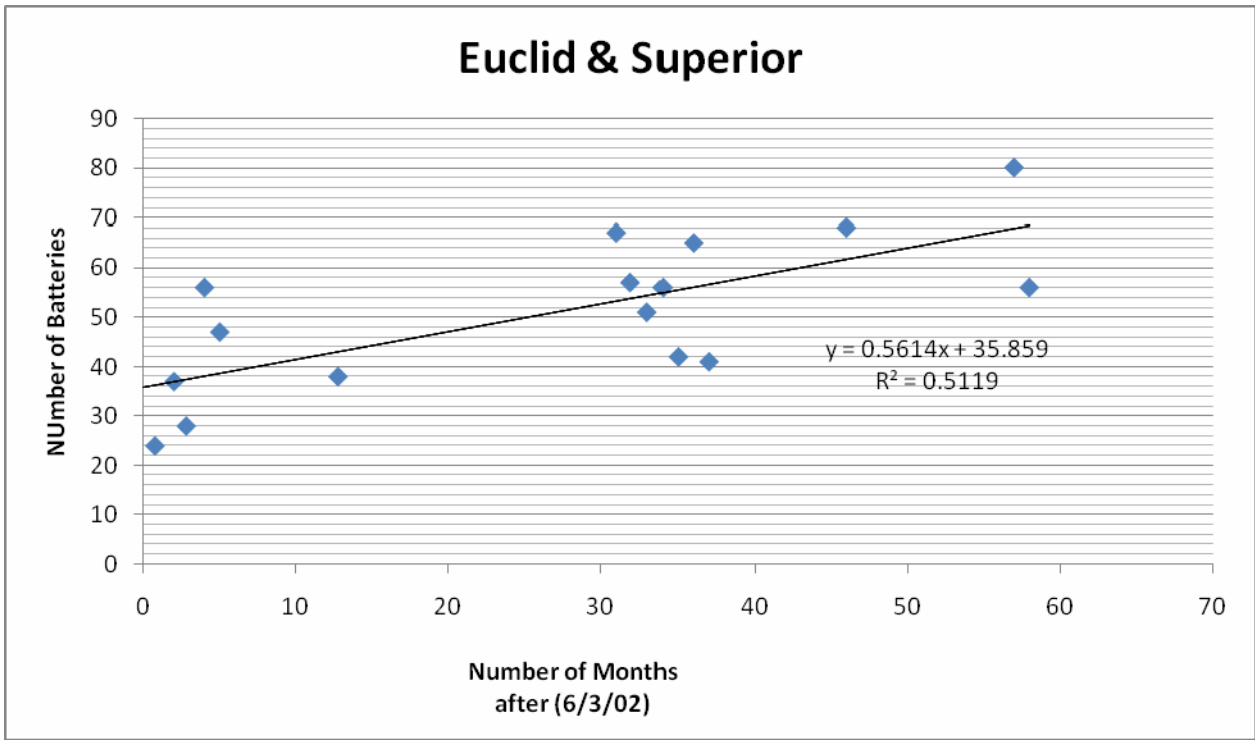


Figure 4: Euclid and Superior Survey results. (First survey of each year has been omitted.)

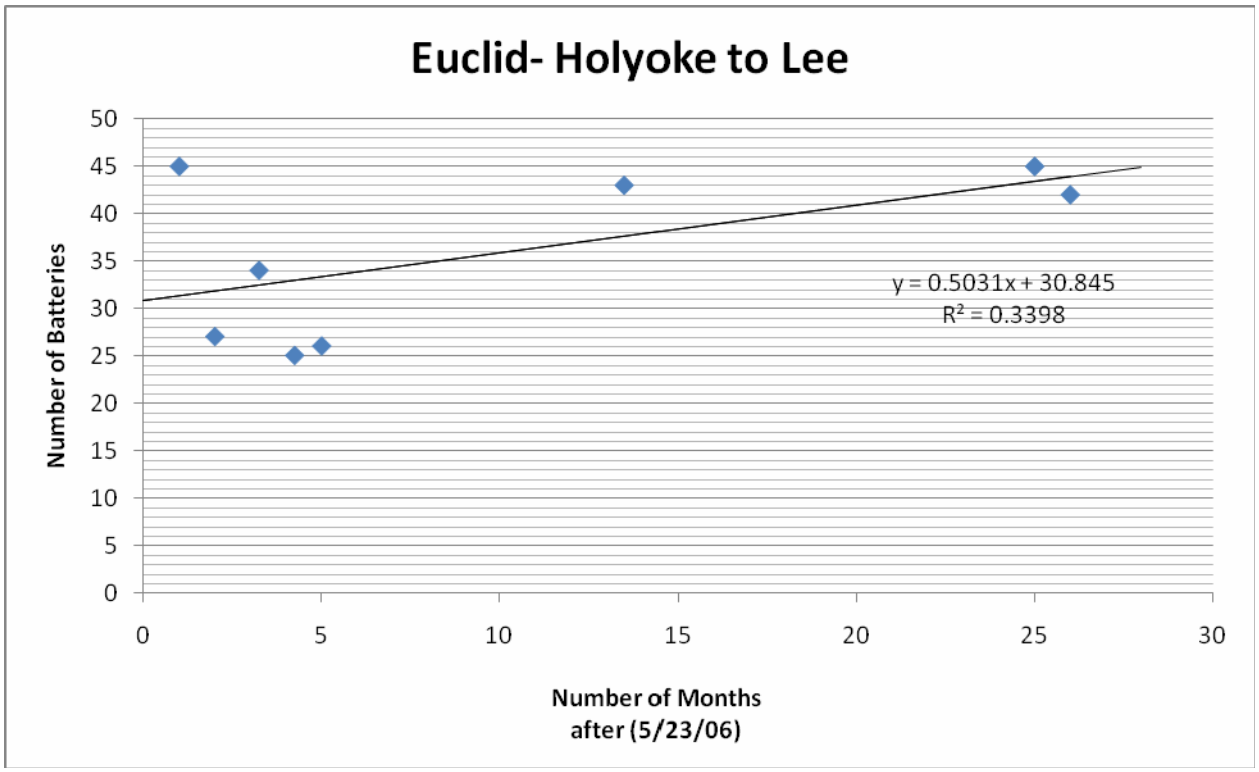


Figure 5: Euclid- Holyoke to Lee Survey results. (First survey of each year has been omitted.)

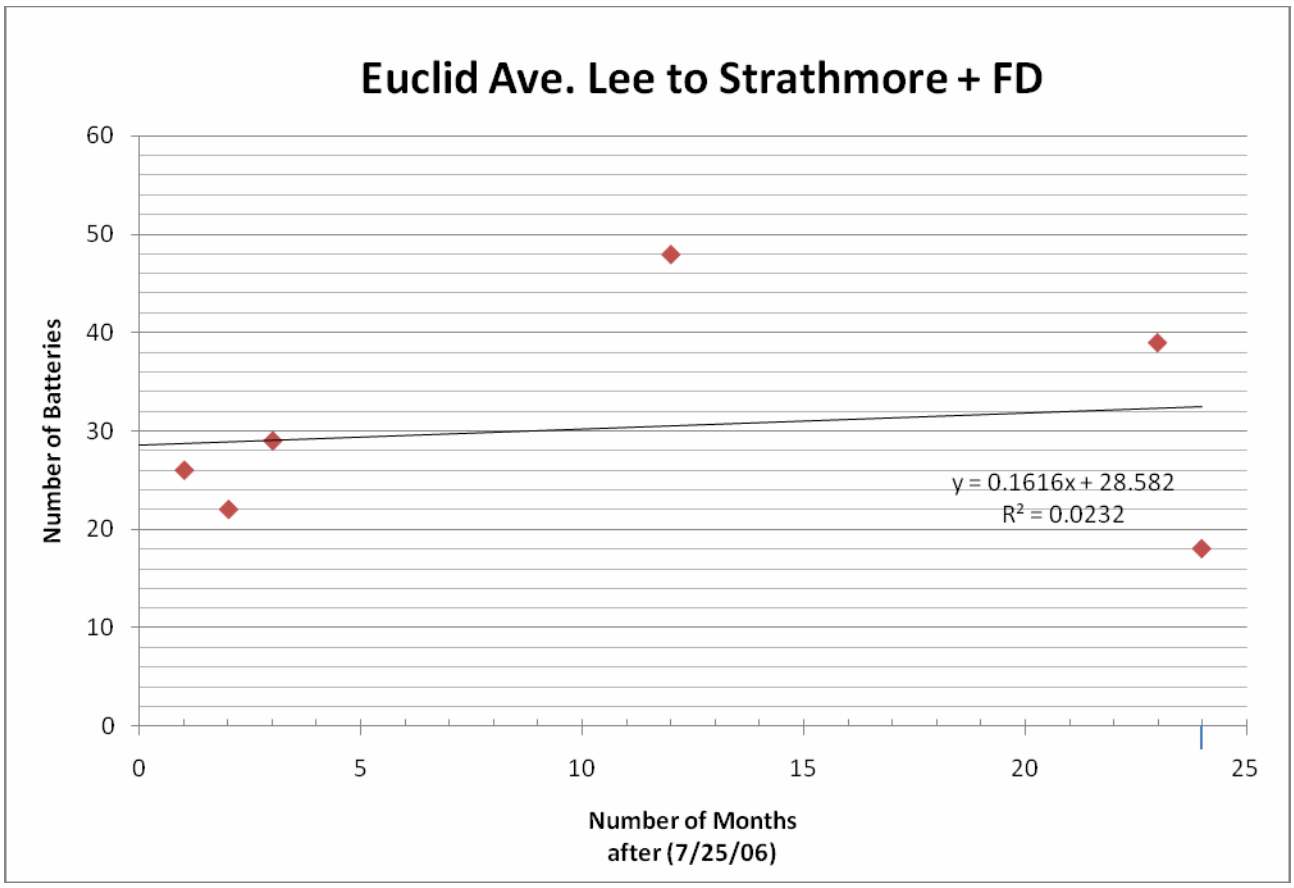


Figure 6: Euclid-Lee to Strathmore Lee Survey results. (First survey of each year has been omitted.)

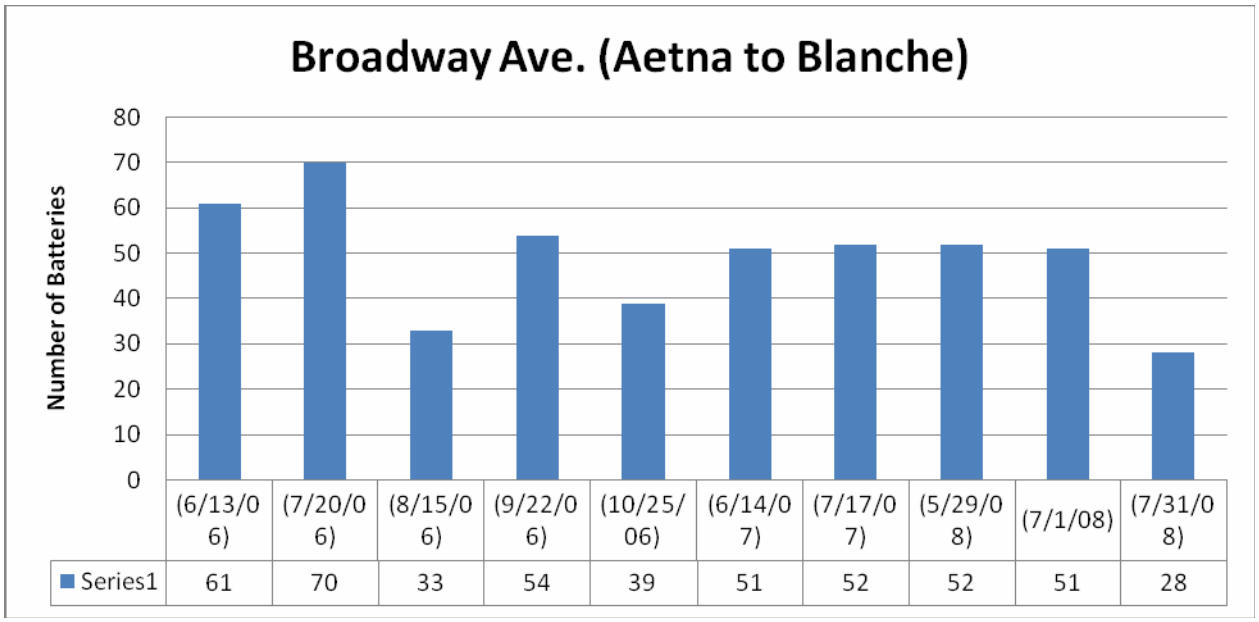


Figure 7: Broadway Site Number of Batteries collected for all surveys.

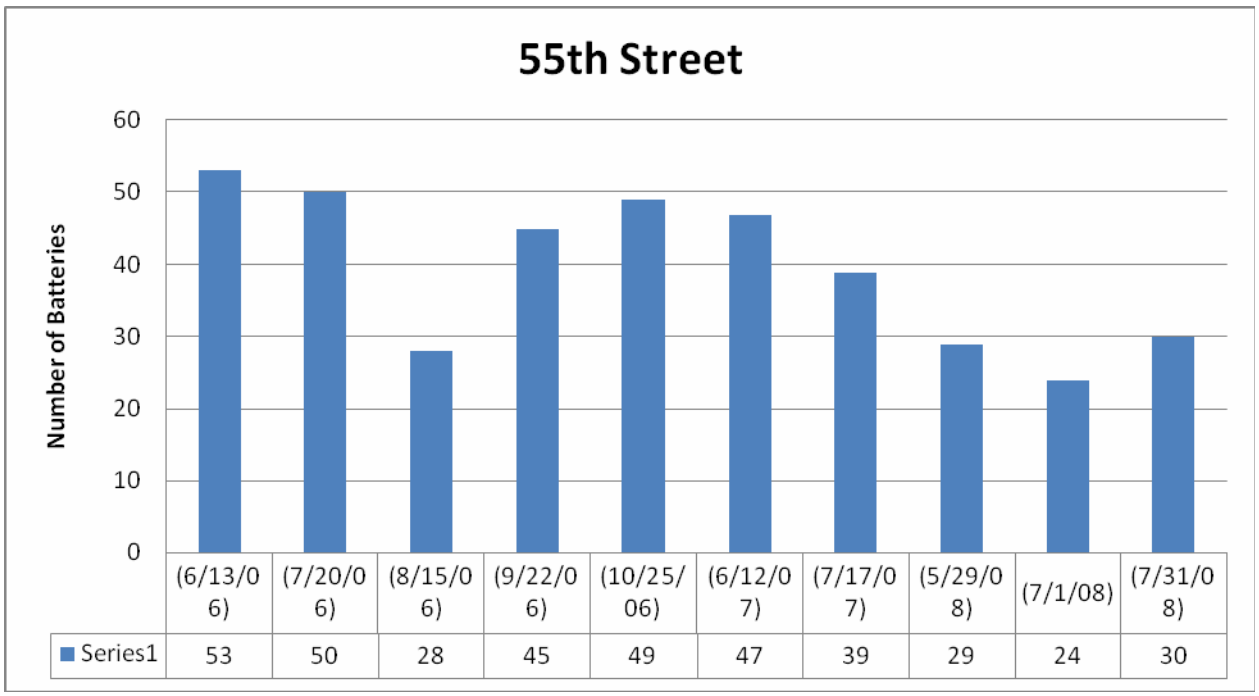


Figure 8: East 55th Site Number of Batteries collected for all surveys

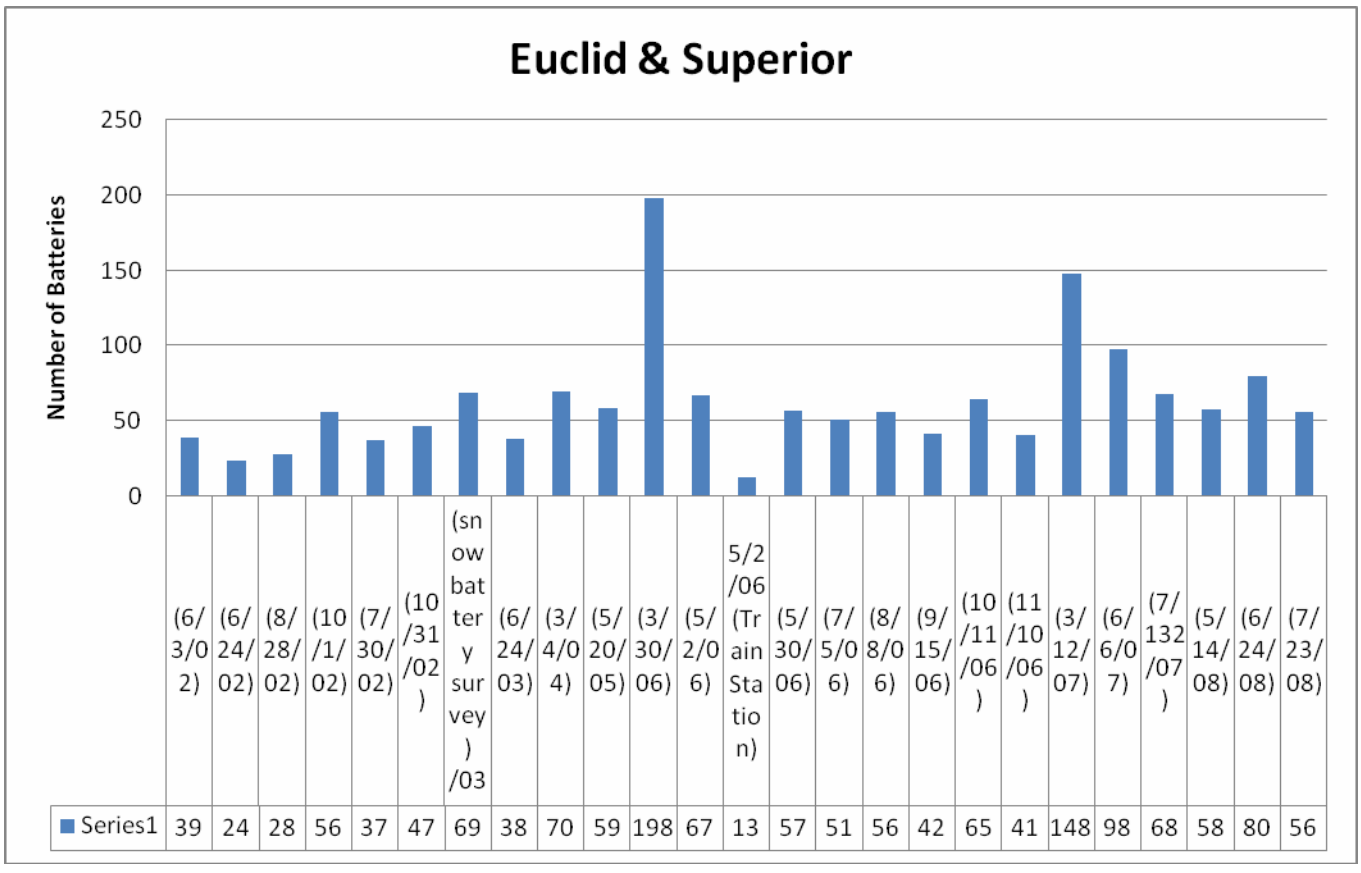


Figure 9: Euclid and Superior Site Number of Batteries collected for all surveys.

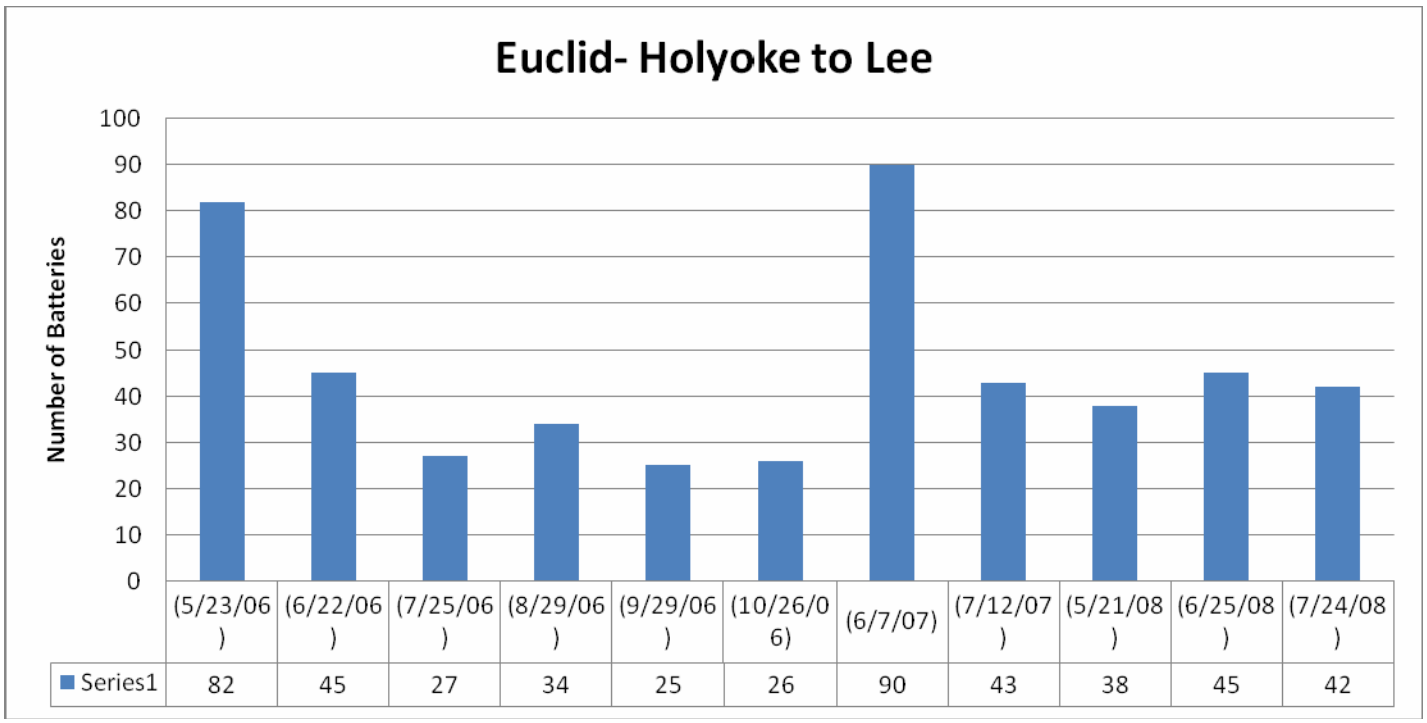


Figure 10: Euclid- Holyoke to Lee Site Number of Batteries collected for all surveys.

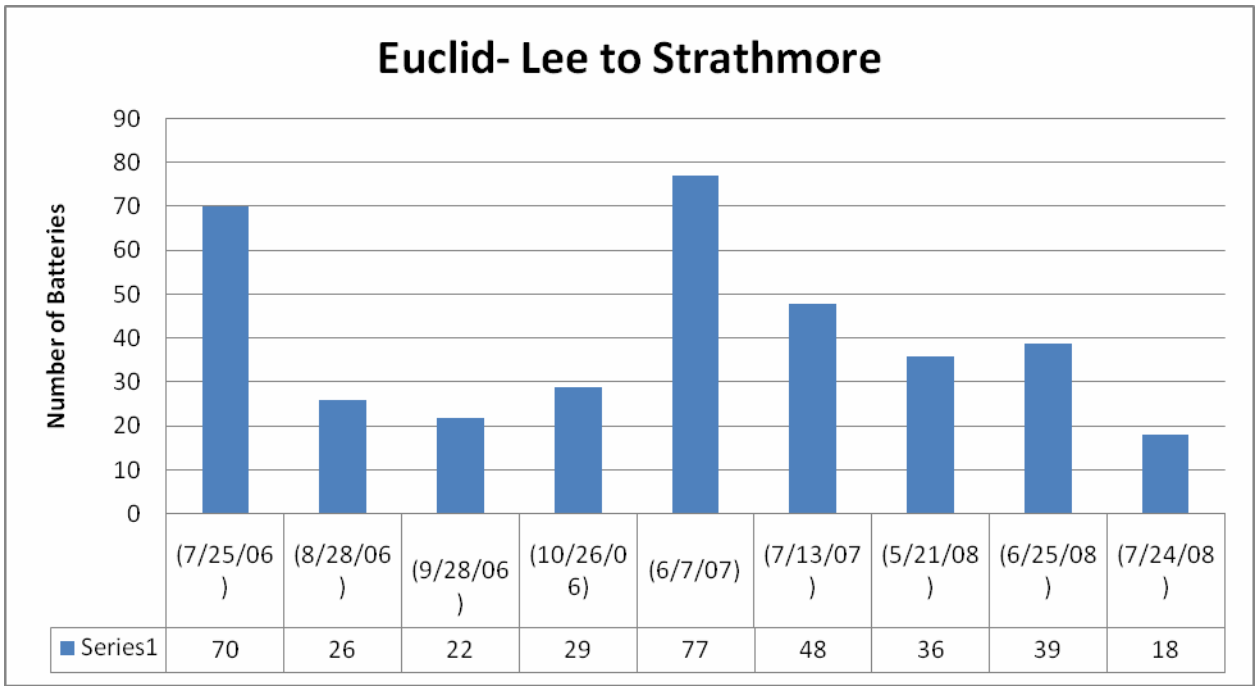


Figure 11: Euclid- Lee to Strathmore Site Number of Batteries collected for all surveys.

Appendix C

Battery Product Identification Guide New Product Update Pages

Paul Manglona

Summer, 2008

Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Duracell Coppertop (China)

Manufacturer: Duracell
Made in: China
Label Languages: Chinese, English
Color: Black with Copper Top
Jacket Type: Paper/Plastic (AA)

This Duracell product does not appear to be for the U.S. market since the dominant labeling is in Chinese. The cells do not have a power check feature. There is a date is printed on the top of the battery, but its meaning is unclear. The cells pictured were recovered in 2008. The cells seem too new to have a "used by" data of 2002. It seems more likely that the date is a date of manufacturer. It is unknown if there are other sizes available for this Chinese version.

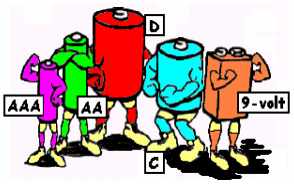
Reference: www.duracell.com

Weight of AA Cells by Date (2002)

Weight (g)					
1.			23.89**		
2.			24.06**		
3.			23.79**		
4.			23.99**		
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
Average					
S.D.					

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				



Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Energizer e^2 (Version 2)

Manufacturer: Energizer
Made in: USA (AA)
Label Languages: English, Spanish, French
Color: Silver with two thin red strips near the top of the barrel
Jacket Type: Paper/Plastic (AA)

Energizer e^2 (Version 2) batteries appear to be a recent label variation of the original Energizer e^2 Titanium Technology batteries. They have a "best if used by" data but do not have a power check feature. It is not known if they are available in other "Big 5" sizes.

Reference: www.energizer.com

Weight of AA Cells by Date

Battery Weight Matrix (2013)

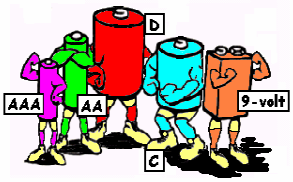
Weight (g)	D	C	AA	AAA	9v
1.			23.49**		
2.			23.46**		
3.			23.48**		
4.					

Battery Weight Matrix (2012)

Weight (g)	D	C	AA	AAA	9v
1.			24.29**		
2.			24.10**		
3.			24.18**		
4.			24.21**		
5.			24.28**		
6.			24.31**		
7.			24.29**		
8.					

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				



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Feral Battery Research Project
Battery Identification Guide

Energizer (Pink)

Manufacturer: Energizer
Made in: U.S.A
Label Languages: English
Color: Pink with a black top
Jacket Type: Paper/Plastic (AA)

These “pink” Energizer batteries were apparently a “special issue” version of the traditional Energizer Battery. They have a “use by” date printed on their top. They do not have a power check feature. It is not known if they are available in other “Big 5” sizes.

Reference: www.energizer.com

Weight of AA Cells by Date (2012)

Weight (g)					
1.			23.72**		
2.			23.77**		
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
Average					
S.D.					

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				

Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Konnoc Super Alkaline

Manufacturer: Konnoc Battery Industrial Co.,Ltd.
Made in: China (AA ,AAA)
Label Languages: English, French, German
Color: Blue, green, and yellow, with black stripes across barrel
Jacket Type: Paper/Plastic (AA, AAA)

Konnoc Super Alkaline Batteries do not have a power check feature, nor do they have a “use by” date printed on their label. It is not known if they are available in other “Big 5” sizes.

Reference: www.konnoc.com

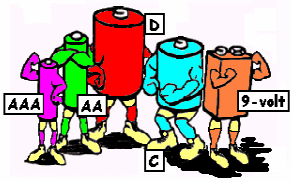
Battery Weight Matrix (Undated)

Weight (g)	D	C	AA	AAA	9v
1.			24.07*	11.33*	
2.			24.37*	11.35*	
3.			24.00*	11.33*	
4.			23.96*	11.36*	
5.			24.16*	11.31*	
6.			24.20*	11.35*	
7.			23.94*	11.30*	
8.			23.92*	11.37*	
9.					
10.					
Average					
S.D.					

*** New from blister packs.**
**** Used from our "used/dead" domestic battery inventory.**

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				



Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Konnoc Ultra Power ACE

Manufacturer: Konnoc Battery Industrial Co., Ltd.
Made in: China
Label Languages: English, French, German
Color: Gray, with black and yellow stripes across barrel
Jacket Type: Paper/Plastic (AA, AAA)

Konnoc Ultra Power Ace Batteries do not have a power check feature. There appears to be a “use by” date printed on the bottom of each cell. It is not known if they are available in other “Big 5” sizes.

Reference: www.konnoc.com

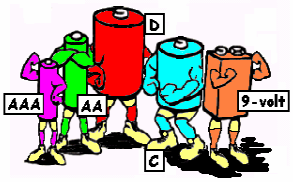
Battery Weight Matrix (Possibly dated on the bottom of the battery)

Weight (g)	D	C	AA	AAA	9v
1.			14.91*	7.69*	
2.			14.99*	7.60*	
3.			14.97*	7.73*	
4.			14.81*	7.70*	
5.			15.09*	7.52*	
6.			15.01*	7.51*	
7.			14.97*	7.55*	
8.			15.09*	7.45*	
9.					
10.					
Average					
S.D.					

*** New from blister packs.**
**** Used from our "used/dead" domestic battery inventory.**

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				



Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Maxell Alkaline

Manufacturer: Maxell
Made in: China (AA)
Label Languages: English, Spanish, French, German
Color: Gold and white, with a blue stripe on the bottom
Jacket Type: Paper/ Plastic (AA)

Maxell Alkaline Batteries do not have “use by” date printed on their labels. Also, there is no power check feature on the battery. It is not known if they are available in other “Big 5” sizes.

Reference: www.maxell.com

Battery Weight Matrix (Undated)

Weight (g)	D	C	AA	AAA	9v
1.			23.12**		
2.			23.25**		
3.			23.16**		
4.			23.17**		
5.			23.16**		
6.			23.23**		
7.			23.25**		
8.			23.05**		
9.			23.24**		
10.			23.16**		
11.			23.22**		
12.			23.44**		
13.			23.07**		
14.			23.11**		
15.			23.22**		
16.			23.43**		
17.			23.26**		
18.			23.39**		
19.			23.24**		
20.			23.02**		
Average			23.21		
S.D.			0.11		

*** New from blister packs.**
**** Used from our "used/dead" domestic battery inventory.**

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				

Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Maxell Alkaline (Japan)

Manufacturer: Hitachi Maxell, Ltd.
Made in: Japan
Label Languages: English, Japanese, Chinese
Color: Black with a gold top and red bottom.
Jacket Type: Paper/ Plastic (AA)

This version of Maxell's Alkaline battery is labeled in Japanese. The cell were probably not manufactured for the U.S. battery market. No "use by" date is present, and there is no power check feature. It is not known if they are available in other "Big 5" sizes.

Reference: www.maxell.com

Battery Weight Matrix (Undated)

Weight (g)	D	C	AA	AAA	9v
1.			23.31**		
2.			23.23**		
3.			23.46**		
4.			23.15**		
5.					
6.					
7.					
8.					
9.					
10.					
Average					
S.D.					

*** New from blister packs.**

**** Used from our "used/dead" domestic battery inventory.**

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				

Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Monster Powercell High Capacity Alkaline

Manufacturer: Monster
Made in: China
Label Languages: English
Color: Red with a gold top
Jacket Type: Paper/ Plastic (AA)

The Monster Power Cell battery does not have a “use by” date printed on its label nor does it have a power check feature. It is not known if they are available in other “Big 5” sizes.

Reference: www.monsterpowercell.com

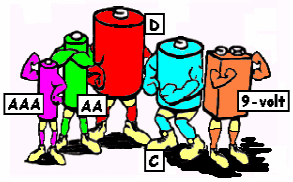
Battery Weight Matrix (Undated)

Weight (g)	D	C	AA	AAA	9v
1.			23.46*		
2.			23.66*		
3.			23.59*		
4.			23.65*		
5.			23.50*		
6.			23.68*		
7.			23.55*		
8.			23.55*		
9.					
10.					
Average					
S.D.					

*** New from blister packs.**
**** Used from our "used/dead" domestic battery inventory.**

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				



Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Panasonic Industrial General Purpose

Manufacturer: Panasonic (Matsushita Electric Industrial Co., Ltd.)
Made in: China
Label Languages: English, Japanese, Chinese
Color: Blue with silver label, white lettering, and white and silver stripes near the top
Jacket Type: Steel Sheath (AA)

The Panasonic R6-AA battery does not have a power check feature. They appear to have a “use by” date printed on the bottom. The cell labeling indicate that these are “Not for Retail Trade”. It is not known if they are available in other “Big 5” sizes.

Reference: www.panasonic.com

Weight of AA Cells by Date (Undated)

Weight (g)					
1.			17.48**		
2.			17.09**		
3.			17.94**		
4.			17.06**		
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
Average					
S.D.					

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				

Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Philips Long Life (Version 2)

Manufacturer: Philips
Made in: China (AA, AAA)
Label Languages: English
Color: Green with a yellow stripe that goes halfway across the barrel.
Jacket Type: Paper/Plastic (AA, AAA)

This "Green" version of Philips Longlife batteries has a "best before" date printed on the bottom of the battery. It does not have a power check feature, and it is also unknown if this type of batter is available in other sizes.

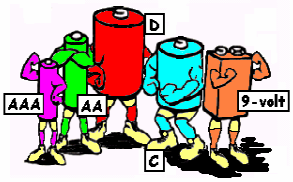
Reference:

Battery Weights

Weight (g)			AA (2008)	AAA (2007)	
1.			14.09**	7.16**	
2.			13.78**	7.25**	
3.			14.44**		
4.					
5.					
Average					
S.D.					

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				



Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Panasonic Power Line Industrial Alkaline

Manufacturer: Panasonic (Matsushita Electric Industrial Co., Ltd.)
Made in: Belgium
Label Languages: English, French, German, Dutch
Color: Black and gold
Jacket Type: Paper/ Plastic (AA)

Panasonic Power Line Industrial Alkaline batteries have numbers printed on the bottom which may indicated a “use by” date, but do not have a power check feature. It is not known if they are available in other “Big 5” sizes.

Reference: www.panasonic.com

Battery Weight Matrix (Possible dated 2011)

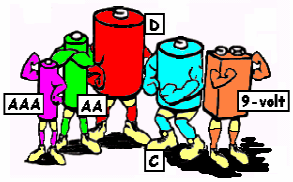
Weight (g)	D	C	AA	AAA	9v
1.			22.73**		
2.			22.81**		
3.			22.75**		
4.					
5.					
6.					
7.					
8.					
9.					
10.					
Average					
S.D.					

*** New from blister packs.**

**** Used from our "used/dead" domestic battery inventory.**

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				



Case Western Reserve University
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Feral Battery Research Project
Battery Identification Guide

Power Pac Plus Super Alkaline

Manufacturer: PowerPacPlus (Distributed by Dynamic Hardware Concepts LLC)
Made in: China (AA)
Label Languages: English
Color: Black with thin gold strips on top and bottom.
Jacket Type: Paper/Plastic (AA)

Power Pac Plus batteries have a “best if used by” date near the top of the battery, but do not have a power check feature. It is not known if they are available in other “Big 5” sizes.

Reference: Distributor: Dynamic Hardware Concepts LLC,

Plainfield, NJ 07062

Weight of AA Cells by Date (2012)

Weight (g)					
1.			23.93*		
2.			23.81*		
3.			24.02*		
4.			23.73*		
5.			23.90*		
6.			23.78*		
7.			23.79*		
8.			23.78*		
9.			23.88*		
10.			23.82*		
11.			23.84*		
12.			23.84*		
13.			23.96*		
14.			23.74*		
15.			23.96*		
16.			23.84*		
17.			23.82*		
18.			23.91*		
19.			23.76*		
20.			23.85*		
Average			23.85		
S.D.			0.08		

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				

Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Vinnic Super Extra Heavy Duty

Manufacturer: Vinnie
Made in: Unknown
Label Languages: English
Color: Black, with green stripe around bottom, silver top, and blue lettering.
Jacket Type: Steel Sheath

This may be a new label variation of the Vinnic Super Heavy Duty battery. No power check feature is present on the battery, and its origin is not indicated on its label. There appears to be a “use by” date stamped on the bottom. It is unknown if there are other sizes available for this battery.

Reference: www.vinnic.com

Weight of AA Cells by Date (Undated)

Weight (g)					
1.			17.00**		
2.			15.87**		
3.			15.99**		
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
Average					
S.D.					

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				

Case Western Reserve University
Department of Civil Engineering
Feral Battery Research Project
Battery Identification Guide

Vinnic Ultra Extra Heavy Duty

Manufacturer: Vinnic
Made in: Unknown
Label Languages: English
Color: Black, with orange lettering, a green stripe near bottom, and a silver top
Jacket Type: Steel Sheath (AA)

This may be a new label variation of the Vinnic Extra Heavy Duty battery. No power check feature is present on the battery, and its origin is not indicated on its label. There appears to be a “use by” date stamped on the bottom.

Reference: vinnic.com

Battery Weight Matrix

Weight (g)	D	C	AA	AAA	9v
1.			17.70**		
2.			17.75**		
3.			17.82**		
4.			17.66**		
5.			17.75**		
6.			17.82**		
7.			17.89**		
8.			17.64**		
9.					
10.					
Average					
S.D.					

*** New from blister packs.**
**** Used from our "used/dead" domestic battery inventory.**

Initial AA Cell Zn Release Test

Replicate	Cell Voltage (v)	pH	Specific Conductance (mmhos)	Zn (mg/l)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
Replicate Average				
Standard Deviation				

Appendix D

Research Report on Soil Standards for Central American and English Speaking Caribbean Countries

Mikhail Miller

Summer, 2008

Research Report on Soil Standards for Central American and English Speaking Caribbean Countries

Mikhail Miller

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Cleveland OH, 44106
mikhail.miller@yahoo.com

As the world becomes more industrialized the problem of pollution becomes more of an issue. As more goods are produced more waste products are being produced as well. A lot of the waste products that are produced from industrial practices turn out to be hazardous to the environment. As a result of poor waste disposal practices from factories and other areas, a significant amount of the waste ends up in the environment resulting in pollution and contamination of precious natural resources. Although more emphasis is being placed on preserving our natural resources countries tend to over look the resource of soil.. The city of Cleveland in the United States is littered with brownfields. Most of which were once foundries that produced steel and machining, stamping, plating and finishing operations that turned steel into products.(Jennings 2005) After more than 100 years of industry the soil, especially around the brownfields, have become heavily polluted by heavy metal contamination. The heavy metals, Cadmium, Chromium, Copper, Nickel, Lead, Zinc, Arsenic and Mercury occur naturally however excess amounts can have adverse effect on plant life. Excess heavy metals in the soil can result in the stunted growth or poisoning of plants in that area. Also other organics from pesticides and insecticides may also be hazardous to the health of the organisms that depend on the soil.

After extensive research, the USEPA (U.S Environmental Protection Agency) put into place regulatory guidance values or soil standards. These values give the maximum allowable limit of heavy metals and other contaminants that are allowed in the soil. Other countries around the world have also engaged in similar endeavors. The purpose of my research was to identify countries in Central America and some countries in the English speaking Caribbean that had similar standards set in place.

The research was conducted over the internet in a systematic manner starting with the Central American countries. First the government websites were searched. Special attention was given to the ministries or departments that were responsible for Agriculture and Environment. Legislatures concerning the environment were also investigated to see if any laws had been passed that addressed soil contamination and soil standards. Emails were sent to individuals in the relative government ministries asking them to aid in the research by providing any information that may have been of help. The U.S embassies in those countries were contacted via email and asked for assistance. Also the embassies of Central American countries in the U.S were also contacted and asked for assistance. If nothing was found from the government websites then a more general search was done using search engines such as Google and Yahoo. In some cases there were documents that were found that indicated that soil standards existed for that a particular country although we could not find them on the government websites. If papers on the subject were found then the author or authors of the paper were emailed and asked for assistance. If no information about soil standards for a particular country was found then a new search would begin for another.

No standards were found for any of the seven countries located in Central America. However it is important to note that there was a language barrier and this may have affected my ability to find them. Apart from Belize all the other six countries are Spanish speaking countries and as a result the web pages were written in Spanish. Online webpage translators were used to translate the web pages to English however in many cases the translations did not always make sense. 7 English speaking Caribbean countries were investigated but only one had any standards.

Central American Countries that were Investigated

Central American Countries	Standards Found	Web sites visited
Belize	No	Government websites: http://www.governmentofbelize.gov.bz/ http://www.embassyofbelize.org/
Costa Rica	No	http://www.mag.go.cr/ http://www.minae.go.cr/ http://www.costarica-embassy.org/
El Salvador	No	http://www.marn.gob.sv/ http://www.elsalvador.org/embajadas/eeuu/home.nsf/home
Guatemala	No	http://www.guatemala.gob.gt/ http://www.consulguatechicago.org/
Honduras	No	http://www.gob.hn/ http://www.hondurasemb.org/
Nicaragua	No	http://www.magfor.gob.ni/ http://www.marena.gob.ni/ http://www.traveldocs.com/namer-map.htm

Panama	No	http://www.anam.gob.pa/ http://www.mida.gob.pa/

The Caribbean Countries that were Investigated

Countries	Standards Found	Websites visited
Antigua and Barbuda	No	http://www.ab.gov.ag/gov_v2/index.php http://environmentdivision.info/
Bahamas	No	http://laws.bahamas.gov.bs/ baic.gov.bs/ www.best.bs
Barbados	No	http://www.barbados.gov.bb/ www.**embassy**.org/**embassies**/bb.html
Jamaica	Yes	http://www.jis.gov.jm/ http://www.eco-web.com/register/04777.html
St. Lucia	No	www.**stlucia**.gov.lc/
U.S Virgin islands	No	http://www.gov.vi/
British Virgin Islands	No	http://www.bvi.gov.vg/products.asp?iCat=11&hierarchy=0

There were a few major limitations in this experiment. The major one was the inability of the researcher to speak Spanish. Although web page translators were used, they often times proved to be ineffective in giving a fairly good translation. Another limitation was that the information that was being researched may not have been in an electronic

form. Many of these countries are still in the process of updating their websites. The information that was needed simply may not have been updated as yet.

Although no information about the soil standards were found it does not mean that standards for those countries do not exist. However there are some countries that are more likely to have standards than others. Countries that are territories of other larger nations may use the standards of the larger nation. For example it is possible that countries like U.S Virgin Islands may use USEPA standards to regulate its soil. The British Virgin Islands may use British standards to regulate soil pollution in that country.

Appendix E

Analysis of Soil Remediation Standards in South American Countries

Maurice Gayle

Summer, 2008

Analysis of Soil Remediation Standards in South American Countries

Maurice Gayle

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Introduction

The industrialization of third world countries over the last century has not only changed the quality of life of the people there but also their surrounding environment. South American oil production and agricultural dominant countries in particular have gone through major changes. With the increasing demand for oil and money earned from agriculture, these countries utilize methods to increase their yield; methods which may include using stronger fertilizers and building more oil refineries. However, while implementation of these methods maybe good for the development of South American countries, often times it can have a very negative impact on the environment and on the health of individuals living in these countries. Fertilizers, gasoline and industrial waste are all possible pollutants of the soil; they can contaminate the soil with heavy metals, BTEX (Benzene, Toluene, ethylbenzene or xylenes) and other forms of toxic inorganics. Therefore, in order lessen the impact that these contaminants have on the soil most South American countries have develop certain regulations to monitor the amount of pollutants present in the soil based on the impact that it will have on human health. The standards that these countries and others worldwide use are referred to as Regulatory Guidance Values (RGVs). RGVs are publicized based on site classifications such as residential, commercial, industrial, agricultural, park, or proximity to surface or ground water. Residential surface soil RGVs are determined based on the impacts to children, while commercial and industrial RGVs are usually based on an adult worker's exposure. Regulatory guidance values define action thresholds for

soil contamination levels. Generally, levels below RGVs require no action. Contamination above RGVs require action to reduce the consequences of contamination or to demonstrate that consequences are acceptable are acceptable for site specific conditions. Many countries around the world have RGVs however; an analysis of the individual RGVs for different countries has shown that there are many inconsistencies in the acceptable RGVs for different contaminants. The reason for these inconsistencies is that RGVs originate from many different sources, hence the reason for the varying degrees of inconsistency, differences as high as 7 orders of magnitude has been discovered. The purpose of this paper therefore is to provide an analysis of the Regulatory Guidance Values (RGVs) of South American countries, so that opportunities for variability can be reduced.

Method

Most of the research in locating the RGVs for South American countries was done via the internet i.e. using Google and other search engines such as yahoo, science databases, government websites and also through emails sent to various embassies representing those countries. The results from these searches usually produce results showing either research done by other credible sources that provide references for the RGVs for individual countries or direct RGVs from the government websites. Also the UN international RGVs were found using their environmental agency and the Embassies sent emails with links to specific governmental sectors where standards could be found.

Limitations

- Given that research was regarding Latin American countries and the researcher's official language is English with limited knowledge of Spanish, a lot of translation had to be done using third party language translating software. Although most of the time using this software gave positive results, other times due to the nature of the web page translations could not be made; hence important information may have been overlooked.
- Another limitation faced was that many of these third world countries did not have official government websites where information could be easily located.

Analysis

There are twelve (12) countries in South America namely, Brazil, Argentina, Columbia, Venezuela, Ecuador, Chile, Uruguay, Guyana, Suriname, Peru, Bolivia and Paraguay. Of the twelve only four (4) of these countries have registered Soil Regulatory Values (RGVs), the four include: Brazil, Argentina, Ecuador and Bolivia.

Table Showing South American Countries with RGVs

Country	Standards
Argentina	Yes
Brazil	Yes
Bolivia	Yes
Chile	No
Columbia	No
Ecuador	Yes
Guyana	No
Paraguay	No
Peru	No
Suriname	No
Uruguay	No
Venezuela	No

Conclusion

This analysis showed that RGVs of only 33.3% of South American countries were found. This does not mean that standards do not exist for the remaining percentage, what it means is that these standards may not be present on the internet or more in-depth searching has to be done.

Appendix F

Briefing Documents for the Most Frequently Regulated Synthetic Organic Chemicals

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Summer, 2008

Hexachlorobenzene (C_6Cl_6) (CAS No. 118-74-1) is a chlorinated hydrocarbon with the molecular formula C_6Cl_6. It is a fungicide formerly used as a seed treatment, especially on wheat to control the fungal disease bunt. It has been banned globally under the Stockholm Convention on persistent organic pollutants. It was also used to make fireworks, ammunition, and synthetic rubber. Currently, there are no commercial uses of hexachlorobenzene in the United States. A study of people in Turkey who ate bread accidentally contaminated with hexachlorobenzene showed that the young children of mothers who it ate it or young children who ate it themselves can have lower survival rates. Nursing infants can be exposed to hexachlorobenzene through breast milk if their mothers have been exposed. Unborn children may also be affected if their mother have been exposed. The people in Turkey who ate the contaminated bread suffered from a liver disease called porphyria cutanea tarda. This disease can cause red-colored urine, skin sores, change in skin color, arthritis, and problems of the liver, nervous system, and stomach. Studies in animals show that eating hexachlorobenzene for a long time can damage the liver, thyroid, nervous system, bones, kidneys, blood, and immune and endocrine systems.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “Hexachlorobenzene” http://www.atsdr.cdc.gov/tfacts90.html. Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology),2005, “Hexachlorobenzene”, CAS#118-74-1”

Chlorobenzene (C_6H_5Cl) (CAS No. 108-90-7) Also known as Monochlorobenzene, Phenyl Chloride, Benzene chloride, Chlorbenzene and Chlorobenzol is the most widely used chlorinated benzenes, mono-Chlorbenzene and has been a major chemical for at least 50 years. It is an important component in the manufacturing of chlorinated pesticides, especially DDT, and in the production of phenol and aniline. Monochlorobenzene principal current use is as a chemical intermediate in the production of chemicals such as nitrochlorobenzenes and diphenyl oxide. These chemicals are subsequently used in the production of herbicides, dyestuffs, and rubber chemicals. Additionally, Monochlorobenzene is used as a solvent in degreasing processes (e.g., in metal cleaning operations), paints, adhesives, waxes and polishes. It is a Colorless, neutral liquid which is insoluble in water. Exposer to Chlorobenzene can problems in the central nervous system such as headache, numbness, dizziness, cyanosis, hyperesthesia, and muscle spasms, after intermittent exposure over 2 years to monochlorobenzene in a mixed chemical environment. It can also cause increased liver weights, hepatocellular hypertrophy, renal degeneration and inflammation.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “Chlorobenzene” http://www.atsdr.cdc.gov/tfacts90.html. Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology),2005, “Chlorobenzene”, CAS# 108-90-7

Lindane ($C_6H_6Cl_6$) (CAS No. 58-89-9) Also known as Cyclohexane, Aalindan, Aficide, Celanex, Chloresene, Hexachloran, Gammalin, Kokotine and Nicochloran. It is an organochlorine insecticide that has been used in agriculture and as a treatment for headlice and scabies. Most of the adverse human health effects reported for lindane have been related to agricultural uses and chronic, occupational exposure of seed treatment workers to agricultural-grade lindane. Exposure to large amounts of lindane can harm the nervous system, producing a range of symptoms from headache and dizziness to seizures, convulsions and more rarely death. Adverse hematologic effects have also been reported with chronic occupational exposures and excessive dermal applications; however, a direct cause and effect has not been established. Vomiting and nausea are usual symptoms associated with oral ingestions of lindane but serious neurologic effects can occur, albeit less frequently. The most common side effects with topical use of lindane medications are nonserious reactions of the skin, including burning, itching, dryness and rash.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “Lindane” http://www.cdc.gov/niosh/idlh/110827.html. Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Sstandard and Technology),2005, “Lindane”, CAS# 58-89-9

1, 1 Dichloro-ethene ($C_2H_2Cl_2$) (CASNo. 75-35-4) Other names include Ethylene, 1,1-dichloro-, Sconatex, Vinylidene chloride, 1,1-DCE and Ethylene. It is an organochloride which is a highly flammable, colorless liquid with a sharp, harsh odor. It is insoluble in water, but soluble in ethanol, diethyl ether, acetone, benzene, and chloroform. It is used as a comonomer in the polymerization of vinyl chloride, acrylonitrile, and acrylates and in semiconductor device fabrication for growing high purity silicon dioxide (SiO_2) films. The health effects from exposure to 1,1-DCE are primarily on the central nervous system, including symptoms of sedation, inebriation, convulsions, spasms, and unconsciousness at high concentrations. Also s with other unsaturated carbon compounds, 1,1-DCE can be polymerised to form polyvinylidene chloride. A very widely used product, cling wrap, or Saran was made from this polymer.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “1, 1 Dichloro-ethene” http://www.atsdr.cdc.gov/tfacts39.html. Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology),2005, “1,1 Dichloro-ethene”, CAS# 75-35-4

1, 2 Dichloro-benzene ($C_6H_4Cl_2$) (CAS No. 95-50-1), Also known as Benzene, o-dichloro-, Cloroben and Dichlorobenzene. It is an organic compound used primarily as a high-boiling solvent. It is a benzene derivative with two chlorine atoms substituted at adjacent positions. It is a colorless liquid that is insoluble in water, but is miscible with ethanol, diethyl ether and benzene. It is also used as a solvent for waxes, gums, resins, tars, rubbers, and oils. It is a preferred solvent in some chemical reactions involving fullerenes. It is also used as a degreasing agent for metals, leather and wool. 1,2-Dichlorobenzene has been shown to cause eye and respiratory irritation in humans at exposure levels above 100 ppm. Skin irritation has been observed following dermal application in humans and animals.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “1,2 Dichlorobenzene” http://www.atsdr.cdc.gov/tfacts10.html . Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology),2005, “1,2 Dichlorobenzene”,

CAS#95-50-1

1, 2 Dichloroethene ($C_2H_2Cl_2$) (CAS No. 156-60-5) commonly called **1,2-dichloroethylene** or **1,2-DCE**, is an organochloride which is highly flammable, colorless liquid with a sharp, harsh odor. It can exist as either of two geometric isomers, *cis*-1,2-dichloroethene or *trans*-1,2-dichloroethene, but is often used as a mixture of the two. It is minimally soluble (5090 mg/L for the cis-isomer) in water, and soluble in ethanol, diethyl ether, acetone, benzene, and chloroform. 1,2-DCE is used as a solvent for waxes, resins, polymers, fats, and lacquers. It is also used as an intermediate in the preparation of other chlorinated solvents. The major health effect of inhalation of vapors of 1,2-DCE is narcosis; it has been used in a combination with diethyl ether as an anesthetic. In high concentrations, exposure to 1,2-DCE causes central nervous system depression; in milder exposures, it can produce nausea, vomiting, weakness, tremor, epigastric cramps, burning of the eyes and vertigo.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “1,2 Dichloroethene” http://www.atsdr.cdc.gov/tfacts87.html . Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology), 2005, “1,2 Dichloroethene”,

CAS# 156-60-5

1,1,2-Trichloroethane ($C_2H_3Cl_3$) (CAS No. 79-00-5) 1,1,2-Trichloroethane also known as 1,1,2-TCA is a colorless, sweet-smelling liquid. It does not burn easily, can be dissolved in water, and evaporates easily. It is used as a solvent and as an intermediate in the production of the chemical, 1,1-dichloroethane. 1,1,2-Trichloroethane is sometimes present as an impurity in other chemicals, and it may be formed when another chemical breaks down in the environment under conditions where there is no air. Trichloroethane may be harmful by inhalation, ingestion and skin contact. It is a respiratory and eye irritant. Although no definitive studies currently exist, trichlorethane should be treated as a potential carcinogen since laboratory evidence suggests that low molecular weight chlorinated hydrocarbons may be carcinogenic. 1,2-TCA is a central nervous system depressant and inhalation of vapors may cause dizziness, drowsiness, headache, nausea, shortness of breath, unconsciousness, or cancer.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “1,1,2-Trichloroethane” http://www.atsdr.cdc.gov/tfacts148.html. Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology), 2005, “1,1,2-Trichloroethane“ , CAS#79-00-5

1,4-Dichlorobenzene ($C_6H_4Cl_2$) (CAS No. 106-46-7) 1,4-Dichlorobenzene occurs as colorless or white crystals (monoclinic prisms or leaflets) with a distinctive aromatic odor, similar to mothballs. It is practically insoluble in water and soluble in ether, chloroform, carbon disulfide, benzene, alcohol, and acetone. 1,4-Dichlorobenzene is noncorrosive, volatile, and combustible. 1,4-Dichlorobenzene is flammable when exposed to heat, flame, or oxidizers. When it is heated to decomposition, toxic gases and vapors (such as hydrochloric acid and carbon monoxide) are released. For the past 20 years 1,4-dichlorobenzene has been used primarily as a space deodorant in products such as room deodorizers, urinal and toilet bowl blocks, and as an insecticide fumigant for moth control. It is also used as an intermediate in the production of polyphenylene sulfide, a plastic used in the electrical and electronics industries. The remainder of the 1,4-dichlorobenzene produced is used as a germicide/disinfectant; a soil fumigant; an insecticide for fruit borers and ants; a pesticide; an animal repellent; a chemical intermediate in the production of a variety of yellow, red, and orange pigments; in the manufacture of air deodorizers, dyes, pharmaceuticals, and resin-bonded abrasives; and as an agent to control mold and mildew growth on tobacco seeds, leather, and some fabrics. The US Department of Health and Human Services (DHHS) has determined that p-DCB may reasonably be anticipated to be a carcinogen, although there is no direct evidence. People who have eaten 1,4-dichlorobenzene products regularly for long periods (months to years) developed skin blotches and anemia. 1,4-Dichlorobenzene might cause a burning feeling in your skin if you hold mothballs or toilet-deodorizer blocks against your skin for a long time. Breathing or eating any of the dichlorobenzenes caused harmful effects in the liver of laboratory animals. Animal studies also found that 1,2- and 1,4-dichlorobenzene caused effects in the kidneys and blood, and that 1,3-dichlorobenzene caused thyroid and pituitary effects.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “1,4-Dichlorobenzene” http://www.atsdr.cdc.gov/tfacts10.html. Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology), 2005, “1,4-Dichlorobenzene”, CAS#106-46-7

Dieldrin ($C_{12}H_8Cl_6O$) (Cas. No 60-57-1) is a chlorinated hydrocarbon originally produced in 1948 by J. Hyman & Co, Denver, as an insecticide. The molecule has a ring structure based on naphthalene. Dieldrin is closely related to aldrin which itself breaks down to form dieldrin. Aldrin is not toxic to insects, it is oxidised in the insect to form dieldrin which is the active compound. Originally developed in the 1940s as an alternative to DDT, dieldrin proved to be a highly effective insecticide and was very widely used during the 1950s to early 1970s. Endrin is a stereoisomer of dieldrin. People who intentionally or accidentally ingested large amounts of aldrin or dieldrin suffered convulsions and some died. Health effects may also occur after a longer period of exposure to smaller amounts because these chemicals build up in the body. Some workers exposed to moderate levels in the air for a long time had headaches, dizziness, irritability, vomiting, and uncontrolled muscle movements. Workers removed from the source of exposure rapidly recovered from most of these effects. Children can be exposed to aldrin and dieldrin in the same way as adults. There are no known unique exposure pathways for children. Children who swallowed amounts of aldrin or dieldrin much larger than those found in the environment suffered convulsions and some died, as occurred in adults. However, it is not known whether children are more susceptible than adults to the effects of aldrin or dieldrin. It is known that both aldrin or dieldrin cause birth defects in humans. Pregnant animals that ingested aldrin or dieldrin had some babies with low birth weight and some with alterations in the skeleton. Dieldrin has been found in human breast milk; therefore, it can be passed to suckling infants.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “Dieldrin” http://www.atsdr.cdc.gov/tfacts1.html. Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology) ,2005, “Dieldrin”, CAS# 60-57-1

1,1 Dichloroethane ($C_2H_4Cl_2$) (CAS No. 75-34-3) is a chlorinated hydrocarbon. It is a colorless oily liquid with a chloroform-like odor. It is not easily soluble in water, but miscible with most organic solvents. It is mainly used as a feedstock in chemical synthesis, chiefly of 1,1,1-trichloroethane. It is also used as a solvent for plastics, oils and fats, as a degreaser, as a fumigant in insecticide sprays, in halon fire extinguishers, and in cementing of rubber. It is used in manufacturing of high-vacuum resistant rubber and for extraction of temperature-sensitive substances. Very limited information is available on the effects of 1,1-dichloroethane on people's health. The chemical was discontinued as a surgical anesthetic when effects on the heart, such as irregular heartbeats, were reported. Studies in animals have shown that 1,1-dichloroethane can cause kidney disease after long-term exposure to high levels in air. Delayed growth was seen in the offspring of animals who breathed high concentrations of the chemical during pregnancy.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR) 2006. “1,1 Dichloroethane” http://www.atsdr.cdc.gov/tfacts133.html. Toxicological Profile for Dichlorobenzenes. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

NIST (National Institute of Standard and Technology), 2005, “1,1 Dichloroethane”, CAS# 75-34-3

1,1(2,2,2-trichloroethylidene) bis(4-chlorobenzene) (CAS#: DDT 50-29-3)

This compound is more commonly known as DDT. It is a pesticide that was once used to in the agricultural industry to stop insects from attacking plants and fruits. It was also used to kill insects that carried diseases. In 1972 its use in the U.S was banned due to the adverse effects it had on wildlife and the environment. It enters the environment through the soil. Most of the DDT in the soil is broken down by microorganisms. Half of the DDT content in soil will break down in 2-15 years depending n the type of soil. DDT breaks down to form DDE (dichlorodiphenyldichloroethylene) and DDD (dichlorodiphenyldichloroethane). In air DDT is broken down by the sunlight. This takes about 2 days. DDT and especially DDE are stored in plant and animal fat and tissues. Even though DDT has negative effects on the environment there are some countries that still use DDT. If ingested into the body DDT may cause nervous problem. People who have been exposed to DDT have been reported to experience tremors and seizures until the exposure was stopped. Exposure to DDT may come from eating contaminated food. Infants may be exposed to DDT from drinking contaminated breast milk. Pregnant and nursing mothers should especially be careful. (ASTDR ToxFAQ's, 2002).

Reference:

ASTDR (Agency for Toxic Substances and Disease Registry) (2002). "DDT (**CAS#**: DDT 50-29-3)" Department of Health and Human Services Public Health Service, <http://www.atsdr.cdc.gov/tfacts35.html > [7/18/2008]

Chloroform

This is a colorless liquid with a pleasant, nonirritating fragrance that is slightly sweet in taste. Chloroform was once used as an anesthetic during surgery. Now it is used to make other compounds. Chloroform evaporates easily into the air. As a result the major source of exposure is through the air. Inhaling about 900ppm of Chloroform may result in dizziness, fatigue and headaches. High levels of Chloroform may result in liver and kidney damage. Chloroform may also be form in water when chlorine is added to it. With that being said ingesting large amounts of water containing this compound over long periods of time may also result in liver and kidney damage. (ASTDR ToxFAQ's, 1997).

Reference:

ASTDR(Agency for Toxic Substances and Disease Registry) (1997). "Chloroform CAS # 67-66-3" U.S Department of Health and Human Services Public Health Service, <http://www.atsdr.cdc.gov/tfacts6.html > [7/21/08]

1, 1, 1 Trichloroethane (CAS#: 71-55-6)

This is a synthetic colorless liquid with a a sharp, sweet odor. It is usually found as a liquid but it evaporates easily into vapor. Upon till January 2002 this chemical was manufactured and used as a solvent for things like metal grease and glue. However its manufacturing was disallowed due its ill effects it had on the environment. 1, 1, 1 Trichloroethane gets into the environment mainly as a gas. It takes up 6 years to break down once it is in the air. Once it gets into the air then it may travel up to the ozone layer where it is broken down by sunlight. The chemicals that are released as a result may cause more damage to the ozone layer. Contaminated water from landfills and hazardous waste plants may leak into lakes and rivers or it may seep into underground water sources or it may just stay in the soil. However most of it would evaporate. Breathing in contaminated air may result dizziness, lightheadedness and loss of coordination. These effects will quickly disappear once you have stopped breathing in contaminated air. High levels may result unconsciousness, decrease in blood pressure and cardiac arrest. (ASTDR ToxFAQ's, 2006)

Reference

ASTDR(Agency for Toxic Substances and Disease Registry) (2006) "1, 1, 1 Trichloroethane (CAS#: 71-55-6)" US Department of Health and Human Services Public Health Service, <http://www.atsdr.cdc.gov/tfacts70.html >[7/18/2008]

Pentachlorophenol (CAS#: 87-86-5)

This is a manufactured chemical that does not exist naturally. Pure pentachlorophenol exist as colorless crystals however in its impure state it exists as dark brown dust, beads or even flakes. It was once used as apesticide and also as a wood perservative but its use was restricted to certified applicators. It is still used industrially as a wood preservative for utility poles, railroad ties, and wharf pilings. Pentachlorophenol can be found in the air, water, and soil. It enters the environment through evaporation from treated wood surfaces, industrial spills, and disposal at uncontrolled hazardous waste sites. Pentachlorophenol is broken down by sunlight, other chemicals, and microorganisms into other chemicals within a couple of days to months. Pentachlorophenol is found in fish and other foods, but tissue levels are usually low. Human exposure mostly come from the previously named sources; water, air and soil. People who live near utility poles, wharf pilings or railroad ties have a higher risk of exposure. Also people who live near hazardous waste sites may be at risk of being exposed to higher than normal levels of this chemical. Studies in workers show that exposure to high levels of pentachlorophenol can cause the cells in the body to produce excess heat. When this occurs, a person may experience a very high fever, profuse sweating, and difficulty breathing. The body temperature can increase to dangerous levels, causing injury to various organs and tissues, and even death.(ASTDR ToxFAQ's, 2008)

Reference:

ASTDR(Agency for Toxic Substances and Disease Registry) (2001) "Pentachlorophenol (CAS#: 87-86-5)" US Department of Health and Human Services Public Health Service, <http://www.atsdr.cdc.gov/tfacts51.html > [7/18/2008]

Chloroethene (CAS#: 75-01-4)

Chloroethene, also known as vinyl chloride, is a colorless, flammable gas at room temperature with a sweet smell. This gas is unstable at high temperatures and as a result may explode if it is allowed to get too hot. It is a manufactured gas which does not occur naturally. Vinyl chloride is used to make polyvinyl chloride (PVC) which in turn is used to make plastic. Plastic is used in industry to make a variety of household and industrial products for example pipes, wires, cable coatings and packaging material. Small amounts of vinyl chloride can dissolve in water. Vinyl chloride in water will evaporate easily too if it is near the surface. The liquid form of this compound evaporates easily as well. Due to the ease at which this chemical evaporates Vinyl chloride is generally found in the air. Breathing in excess amounts of this chemical may cause you to feel sleepy and or dizzy. Very large levels may result in eventual death. It has been reported that people who have inhaled large levels of this gas have experienced changes in the liver structure. Some people who work with vinyl chloride have suffered damages to their nervous sytem. If this substance is spilled on your skin then it may result in redness, numbness and blisters. Vinyl chloride is released into the environment from plastics industries, hazardous waste sites, and landfills. Currently there are over 20 different names associated with this chemical. (ASTDR ToxFAQ's, 2008).

Reference:

ASTDR(Agency for Toxic Substances and Disease Registry) (2006) "Chloroethene (CAS#: 75-01-4)" US Department of Health and Human Services Public Health Service, http://www.atsdr.cdc.gov/tfacts20.html [07/17/2008]

Carbon tetrachloride (CAS#: 56-23-5)

-This is a colorless liquid that has a sweet smell. It is a manufactured gas that does not occur naturally. It can be detected in low levels. It evaporates readily in air so as a result it is mostly detected in the gas phase. It has a half life of 30-100 years. It may take several day s for it to be broken down or transformed in soil or water. When it does then it may be changed into chemicals that may be hazardous to the ozone layer. It was used in the production of refrigeration fluid and propellants for aerosol cans, as a pesticide, as a cleaning fluid and degreasing agent, in fire extinguishers, and in spot removers. Because of its harmful effects, these uses are now banned and it is only used in some industrial applications .Exposure to this gas is most due to breathing in contaminated air. Over exposure may lead to liver, kidney and central nervous system damage. (ASTDR ToxFAQ's, 2008).

Reference:

ASTDR(Agency for Toxic Substances and Disease Registry) (2005) "Carbon tetrachloride (CAS#: 56-23-5)" US Department of Health and Human Services Public Health Service, http://www.atsdr.cdc.gov/tfacts30.html [7/17/2008]

Methylene Chloride (CAS#: 75-09-2)

Methylene Chloride also called Dichloromethane, is a colorless, sweet smelling liquid. It is used as an industrial solvent and as a paint stripper. It may also be found in some aerosol and pesticide products and is used in the manufacture of photographic film. Methylene Chloride does not occur naturally in the environment. It is generally released into the environment via the air. It takes approximately 53 to 127 days for half of it to disappear from the air. As a result exposure to this compound is likely to be by breathing in contaminated air. Exposure to this compound may result in dizziness, nausea, and a tingling or numbness of your finger and toes. A person breathing smaller amounts of methylene chloride may become less attentive and less accurate in tasks requiring hand-eye coordination. Skin contact with methylene chloride causes burning and redness of the skin. (ASTDR ToxFAQ's, 2008).

References

ASTDR(Agency for Toxic Substances and Disease Registry)(2001). "Methylene Chloride CAS #75-09-2" US Department of Health and Human Services Public Health Service, http://www.atsdr.cdc.gov/tfacts14.html [7/15/08]

Trichloroethylene (CAS#: 79-01-6)

Trichloroethylene (TCE) is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers. It is not thought to occur naturally in the environment however Trichloroethylene may be found in the air as vapor or it may dissolved in surface water or even underground water sources. This may be as a result of the usage and disposal of chemicals that contain this compound. Some of the Trichloroethylene that maybe found in the soil and water may be broken down by microorganisms. Once in the air it may be broken down by sunlight into other chemicals or it may be return to the soil, surface or ground water by rain. .It does not seem to accumulate in fish or other animals that live in water. If small levels the vapor is inhaled it may result in headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Large amounts may result in impaired heart function, unconsciousness, nerve, kidney, and liver damage and eventual death. Drinking water that is contaminated with this compound in large amounts has the same effect as inhaling it however small amounts may be detrimental to fetal development. (ASTDR ToxFAQ's, 2008). According to the Nationl Institute of Standards and Technology over 50 different names exist for this chemical. The US EPA list 14 of these as 1,2-Trichloroethylene, Acetylene trichloroethylene, Algylen, Anameth, Benzinol, Chlorilen, CirCosolv, Germalgene, Lethurin, Perm-a-chlor, Petzinol, Philex, TRI-Plus M and Vitran. These names are all trade names that associated with the chemical.

Reference:

ASTDR(Agency for Toxic Substances and Disease Registry) (2003) "Trichloroethylene **(CAS#**: 79-01-6)" Department of Health and Human Services Public Health Service, http://www.atsdr.cdc.gov/tfacts19.html [9/15/2008]

USEPA (Environmental Protection Agency) (1999). "National Primary Drinking Water Regulations". <http://www.epa.gov/OGWDW/contaminants/dw_contamfs/trichlor.html>. 22 July 2008

Tetrachloroethylene

Tetrachloroethylene is a nonflammable, colorless liquid that has a sweet odor similar to that of chloroform. It is very volatile and evaporates readily at room temperature. It is generally used as a degreaser for metals and for dry cleaning fabrics. However it is seen as a chemical intermediate for the production of other chemicals (ASTDR CSEM, 2008).Due to its ability to readily evaporate at room temperature this compound is generally found in air and as a result inhalation serves as the greatest risk of exposure. High concentrations of tetrachloroethylene (particularly in closed, poorly ventilated areas) can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death.(ASTDR ToxFAQ's, 2008). The Occupational Safety and Health Administration suggests that the permissible exposure limit in air be 100ppm. The EPA suggest that the maximum contamination level in water is 5 ppb. (ASTDR CSEM, 2008)

Reference:

ASTDR(Agency for Toxic Substances and Disease Registry) (2007) "Tetrachloroethylene Toxicity" Department of Health and Human Services Public Health Service, <http://www.atsdr.cdc.gov/csem/pce/pce_tetrachloroethylene.html > [7/17/08]